AMERICAN ENGINEER AND RAILROAD JOURNAL.

JUNE, 1902.

CONTENTS.

THE STANDARD BOX CAR.

By A. W. Sullivan,

Assistant Second Vice-President Illinois Central Railroad,

President American Railway Association.

At a meeting of the American Railway Association, held in New York, September 5, 1901, the following resolutions were adopted:

"Resolved, That the dimensions of the standard box car be 36 feet in length, 8 feet 6 inches in width and 8 feet in height, all inside dimensions; cross section, 68 square feet; capacity, 2,448 cubic feet. The side-door opening to be 6 feet in width.

"Resolved, That no box cars of larger dimensions than those prescribed for the standard car shall be hereafter constructed, and that all owners and builders of cars be officially notified of the adoption of this resolution.

"Resolved, That the Master Car Builders' Association be requested to consider and adopt the required external dimensions for the standard box car, based upon the interior dimensions, as prescribed by the American Railway Association."

The diagrams of the American Railway Association showing the measurements of the standard box car provide that the length and the width are to be neat measurements between the interior lining of the ends and of the sides of the car, and that the measurement of height shall be from the surface of the floor to the under side of the carline; the purpose being that all the interior measurements of the car shall conform exactly to the dimensions specified.

In 1901 there were in existence 680,000 box cars of the following different lengths:

28 to 30 feet long	85,000 box cars
30 to 33 feet long	110,000 box cars
34 feet long	386,000 box cars
36 feet long	71,000 box cars
Over 36 feet long	28,000 box cars

In the important work of revising the minimum carload weights to conform to the standard box car, which has become the unit for the establishment of such minimums, the classification committees have experienced difficulty in grouping the box cars now in existence, because of the great variation in the actual lengths of the cars, which are found to vary, not only by all the inches of the scale, but also by many fractions of an inch from their nominal lengths. To overcome this difficulty, the American Railway Association, at its meeting April 23, 1902, adopted the following resolution:

"Resolved, That six inches above any given length shall be rated as even length in feet of whatever length it may approximate. Lengths of over six inches shall take the minimum of the next greater length; thus, a length of 38 feet 6 inches shall be rated as a 38-foot car; one of a fraction over 38 feet 6 inches as a 39-foot car."

This provision for grouping the cars of various lengths has application specifically to the cars now in existence, and is not intended to apply to cars hereafter built under specifications for the standard box car.

It is, therefore, within the province of the Master Car Builders' Association, in its function of determining the external dimensions of the standard box car conformably to the internal dimensions fixed by the American Railway Association, to establish standards of dimensions of the constructive parts of the car which shall result in a car that will be standard in respect to all its parts.

It is rarely that such an opportunity is presented of crystallizing a constructive problem into such definite shape, and it is to be hoped that the Master Car Builders' Association will not fail to definitely fix the dimensions allotted to all parts of the standard car so that not only will the exact size of the car be guaranteed, but that the parts may be interchangeable throughout the country, and the railroads reap the fruit of their action in the benefits that will come from the facility with which repairs may be made in the quickest time and at the least expense to any portion of a car in any part of the country.

Delaware, Lackawanna & Western Railroad Company,

Office of President.

I most heartily favor the proposition that the Master Car Builders Association take up, consider and establish standard exterior dimensions for 40-ton box cars to correspond with the American Railway Association standard interior dimensions.

To my mind, it hardly admits of discussion that the more the freight car equipment used by all railroads in this country can be reduced to standard sizes and the parts used in their construction universally standardized, the greater the economy possible in the repair and maintenance of cars on all railroads in this country. Great progress has already been made in this direction, but no one familiar with the matter can for a moment claim that everything has been done to this end that is reasonably possible.

It is most difficult to arrive at any accurate idea of the large additional expense occasioned to the different railroad companies of the country by reason of each company having such a large variety of cars of its own, and the necessity of carrying in stock so many different patterns of the same parts of freight cars. The delay in repairs to freight cars on every road is very much greater by reason of this fact, and when it comes to repairing equipment of other roads, the delay therein owing to the repairing line having to wait until it can get the material from the owner of the car, is infinitely greater and involves the loss of equipment, and expenses in handling the damaged cars, together with furnishing side-track facilities to store them on, must aggregate large sums every year.

To my mind, it is certainly advisable to standardize the entire construction of 40-ton cars, with the possible exception of the roofs, doors, draft gear, bolsters and trucks, and with a body of mechanical men in charge of the work, such as the M. C. B. Association can furnish, there should certainly be no difficulty in getting a standard car which would be recognized as such and be equal, if not superior, to any that can be designed by any single car builder in this country.

I certainly trust that the influence of your journal will be exercised to the fullest extent in favor of this movement.

W. H. TRUESDALE,
President.

Illinois Central Railroad,

Office of Second Vice-President.

With regard to the advisability of extending the standardization to include the actual construction of box cars, I would say that I think this is a step in the right direction.

The interior of the standard box car having been given fixed dimensions, it is possible to establish external dimensions, and in so doing there should be a standardization of all parts of which the car is constructed, to the extent at least of fixing the limit of dimensions where such dimensions will affect adjoining parts or the size of the car as a whole.

These standards of detail should include as nearly as possible every part of the car, so that the lumber, the castings and the forgings may become commercial standards of which the dealers would be willing to carry in stock an ample supply for current requirements, and of which the stock carried by railways could be applied not alone to the repairs of their own cars, but as well to the equipment of any other line.

The saving in the working stock of material that would be effected by the substitution of a limited number of standard parts in wood and metal for the endless variation in form and dimensions of the parts now used for the same purposes would in itself be a strong recommendation for the establishment of standards in the details of construction. A further reason, however, would lie in the refinement and perfection of proportion and design that could be given to the different parts of the car as the result of general experience in its use. The attitude of every observer would be alike, and the knowledge of the weaknesses and defects gained by actual use of the standard car in different parts of the country would quickly crystallize opinion as to the merits or demerits of any question of improvement that might arise, with the result that in a comparatively short time the proportions of the parts could be perfected.

The stability given to the demand for material by having standard specifications would enable dealers to carry large quantities of material in stock in anticipation of orders, and would lessen the cost of production, to the advantage of the railways, in enabling them to obtain quickly the material required of standard quality and at reduced cost.

These are a few ideas that occur to me in connection with this matter. J. T. HARAHAN,

Second Vice-President.

Grand Trunk Railway System,

Office of Third Vice-President.

This company is heartily in accord with any movement that tends to standardize railroad work, and we see no reason why it is not perfectly feasible to construct the 40-ton box cars under discussion so that standard lengths of lumber can be utilized in their construction with minimum waste, and it might be possible for the committee, which is to report on this very important subject, to take the strong points of car construction of the railways of the country, and combine them in a new specification, so as to have a box car that will meet all conditions and be of maximum strength, produced at a reasonable cost, and be free of the many specialties (the best of which might be decided upon and adopted as standard), thus reducing the stock of material at railroad shops, but at all times making it possible for material to be carried by the different companies to insure immediate repairs being made to damaged cars.

We feel that this standardization could be extended to the entire car, to the great benefit of all concerned, and would be glad to see a move made in this direction.

Taking one item in car construction, viz., that of drawbars, the railways could be saved a great burden, so far as expense and stock is concerned, if a standard drawbar could be adopted embracing the strong points of many of the bars now in existence, and eliminating the weak points in many of them, which have been made necessary in order to prevent infringement upon other patents.

This latter suggestion could not, of course, be accomplished by the committee, i. e., designing of a new drawbar, and is referred to merely as one of the many items in car construction where standardization would benefit the railways, in the same manner as the standards adopted by the Westinghouse Company. FRANK W. MORSE,

Third Vice-President.

The Lake Shore and Michigan Southern Railway.

Office of the General Superintendent.

I am very much in favor of standardizing the actual construction of box cars, and believe this is an opportune time for the Master Car Builders' Association to undertake the task. It has been suggested many times in the past, but as there was very little prospect of an agreement upon the inside and outside dimensions of such cars the task of standardizing the details appeared to be a hopeless one. Now, however, the situation is changed materially, in that we have standard inside dimensions, and at the convention of the association this year the outside dimensions that will be recommended by the committee of the association will doubtless be adopted. If the association will now adopt a standard design for the entire car it will be a step in the right direction. From the work the association has done in the past we know that the design adopted will be a good one, and while it may not be followed by all railroads, it will undoubtedly be followed by a great many, and will ultimately effect a great saving in the standardization of materials entering into the repairs of cars. Uniform sizes for the lumber used in repairs and standard patterns for numerous castings will not only reduce the stock of materials that must be maintained by each railroad for the repair of foreign cars, but will save excessive delays in the making of these repairs and increase the mileage of the equipment. The purchasing agent will also find his task materially lightened if the sizes of lumber which he must buy are materially reduced in number.

I see no good reason why a standard car should not be adopted in practically all of its details. No railroad builds its box cars to-day for service on its own lines alone. They become scattered all over the country, and there are no conditions which must be met in building the equipment for one road that are not also imposed upon those designing and building the equipment for another.

W. H. MARSHALL,
General Superintendent.

Southern Pacific Company,

Pacific System.

Respecting the matter of standardizing details of car construction, I would say that this is a consummation which I have long wished for, and I believe the time is approaching when favorable action on the part of mechanical officials of the American railroads will be made possible.

I believe the motive power officials of this country should each be willing to concede minor points and work together for the introduction of standard details of freight car construction. Such action will greatly reduce the cost of repairs, as well as the cost to railways of carrying material for repairs of cars belonging to foreign lines, as well as for cars owned by railway companies themselves.

I see no reason whatever why standard sizes of sills, plates, carlines, purlines, girts, posts, braces, sheathing, lining and roofing cannot be adopted. The only reason why they are not

now of uniform dimensions is probably due to some whim of the individual heads of mechanical departments. Certainly 3-in. siding is as good in every way as 3¼-in. siding, and I see no reason why one-sixteenth or one-eighth of an inch difference should be made in siding or lining, as is now often the case.

Flooring should be also be made of standard sections, so that when it is necessary to make repairs a better and quicker job could be done than at present, where we are obliged to get out sizes and sections to suit the car under repair; or, if material slightly differing from dimensions is used, we are under the necessity of applying repair cards and defect cards for wrong material, with the prospect of future bills from the line owning the car. I do not think there would be any difference of opinion as to the proper strength of material employed, and when that is determined the rest should be easy of accomplishment.

Considerable work in this line has recently been accomplished by the motive power officers of a group of important railway systems under the same control, for which standard cars for the various freight services are being agreed on, together with nearly all details of construction. Nor can I see any good reason why we should not go even further than adopting standard dimensions of wood details. There is no reason why standards governing dimensions of a truck, body bolster, arch bars, oil boxes and draft gears could not also be adopted. I am aware that the standardizing of draft gears, and also trucks, would involve a great deal of discussion, but probably no more so than did the standardizing of journal bearings and oil boxes.

There is no question but that the standardizing of material used in freight equipment would result in a large decrease of cost of car maintenance, and certainly a great saving in time of foreign cars held in repair yards awaiting receipt of material which may have been ordered from the owning road.

From the above you may infer that I am heartily in favor of any movement tending to standardize details of freight equipment.

H. J. SMALL,
Superintendent of Motive Power.

Pere Marquette Railroad Company,

General Manager's Office.

It seems to me that the adoption of standard construction for box cars will have the same beneficial results as came from the adoption of standard sections for rails. I do not have enough technical mechanical ability to suggest any rule on which the construction should be laid down, but now that the inside dimensions have been determined and the experience of a few months has shown that the business of the country can be handled with these inside dimensions, the outside dimensions should follow without great difficulty, and the standardizing of such parts as can be handled in this way would result in great economy of material and time.

S. T. CRAPO,
General Manager.

Buffalo, Rochester & Pittsburgh Railway Company,

President's Office.

I think it very desirable that a standard construction for box cars for all roads should be adopted. There are a good many things, however, in the way of this, some roads being willing to pay for a higher standard and better construction than others. A great many roads use the cheapest of everything, while others use the best, as in our case, and our cars, as a rule, cost considerably more than the cars of other companies. If a high standard could be agreed upon by all roads, then I think a box car standard could be carried out which would be very desirable.

ARTHUR G. YATES,
President.

Fort Worth & Denver City Railway Company,

Office of General Superintendent.

Relative to standardizing box cars in this country, I think that it is the proper thing to do. It will, undoubtedly, cheapen the cost of construction, simplify repairs and make it possible to interchange parts. Inasmuch as at the present time cars go from one section of the country to the other, it cannot be truthfully said that there is any necessity for box cars of various designs and construction to meet the requirements of the different sections of the country. The thing to do is to agree on what would be the best all-round car, settle on that, so far as dimensions are concerned; railroads and builders should lend their energies toward getting the very best construction, and make it standard in all that the name implies.

W. R. SCOTT,
General Superintendent.

Erie Railroad Company.

Office of the President.

The adoption of standard dimensions for all freight car equipment is a proposition that should receive the support of all roads whose interchange of equipment with other companies is of any considerable volume. So far as this company is concerned, it will be pleased to co-operate with others to that end.

F. D. UNDERWOOD,
President.

Burlington, Cedar Rapids & Northern Railway,

Office of the President.

There is no doubt in my mind but what, if standard construction of box cars could be adopted, it would result in a great saving, not only in construction, but in the maintenance of the box cars of the country, and I trust that the efforts in that direction may be entirely successful.

C. J. IVES,
President.

Chicago, Rock Island & Pacific Railway Company,

Office of the General Manager.

This company is committed to the American Railway Association standard for box cars, and is constructing most of its equipment on those lines. Personally, I think it is desirable, and a step in the right direction.

C. A. GOODNOW,
General Manager.

Chicago & Eastern Illinois Railroad Company,

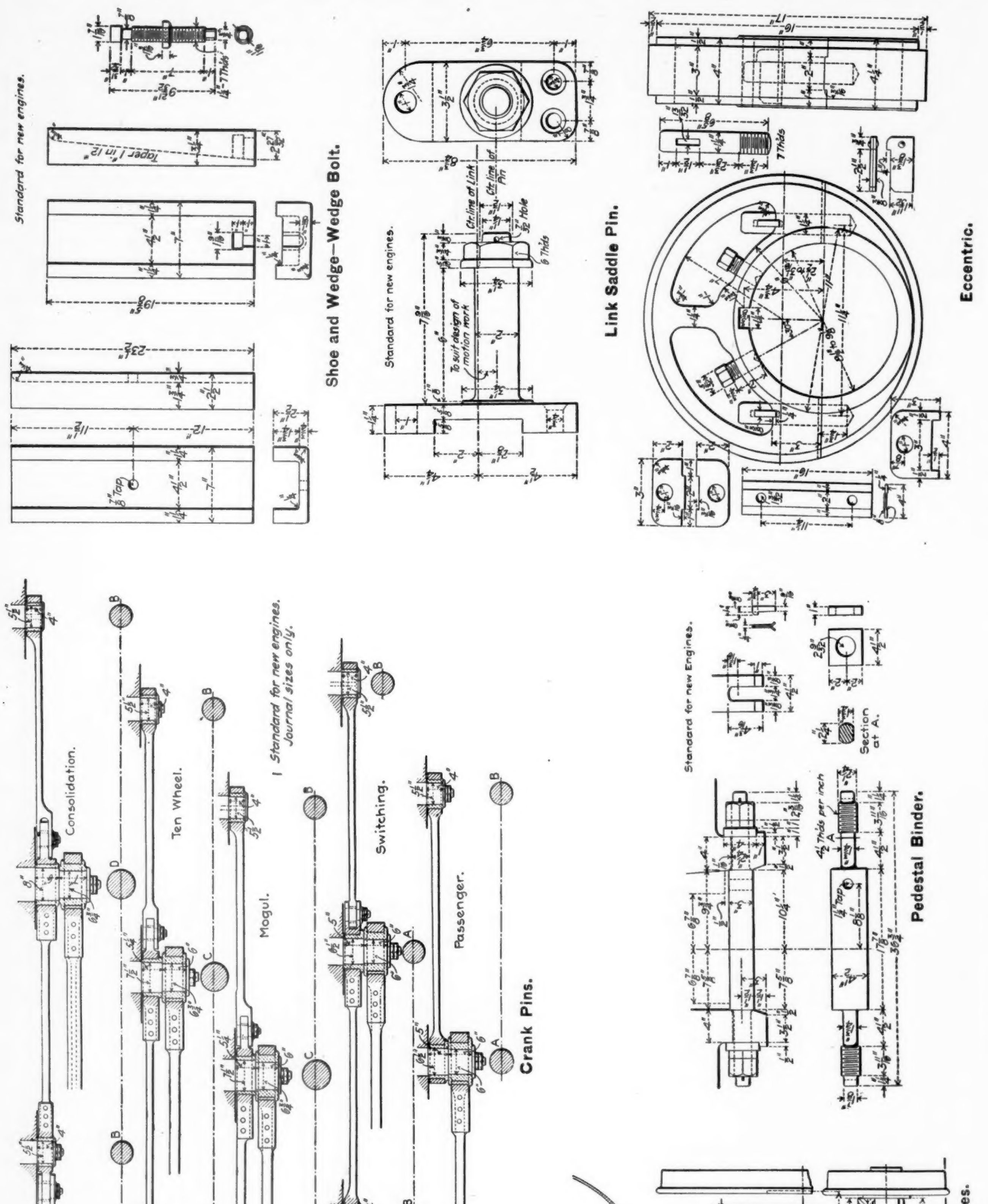
President's Office.

Railroads of the country at large would be benefited by adopting standards where it is possible to do so. The reasons for doing this are obvious. I see no reason why standards for box car construction should not be adopted, as you suggest.

M. J. CARPENTER,
President.

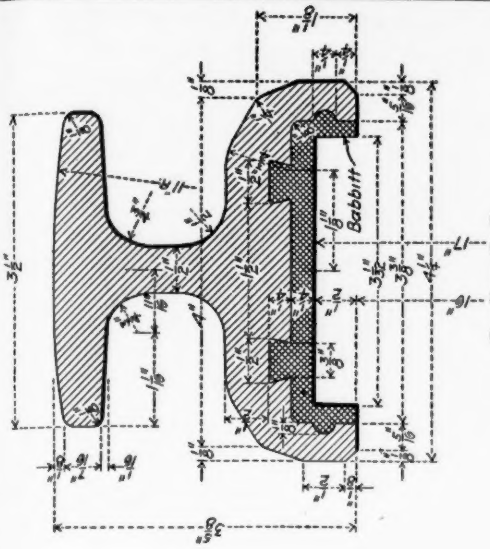
Progress in the application of air brakes to engines and freight cars, up to January 1, 1902, was reported by the American Railway Association at its recent meeting as follows:

Number of members reporting	147
Freight cars in service	1,436,057
Fitted with air-brakes (76½ per cent.)	1,099,099
Engines in service	36,817
Equipped with power brakes (99.1 per cent.)	36,508
New freight cars under contract or construction to be fitted with air brakes	73,465
New engines to be equipped with power brakes	2,175

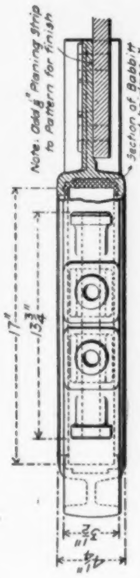


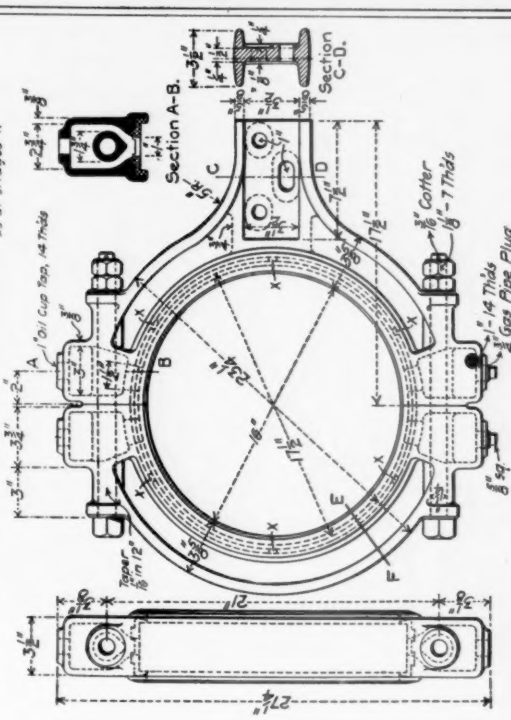
STANDARDS FOR LOCOMOTIVES AND CARS—"THE HARRIMAN LINES."

Union Pacific, Southern Pacific, Oregon Short Line, Oregon Railroad & Navigation Company, Chicago & Alton.

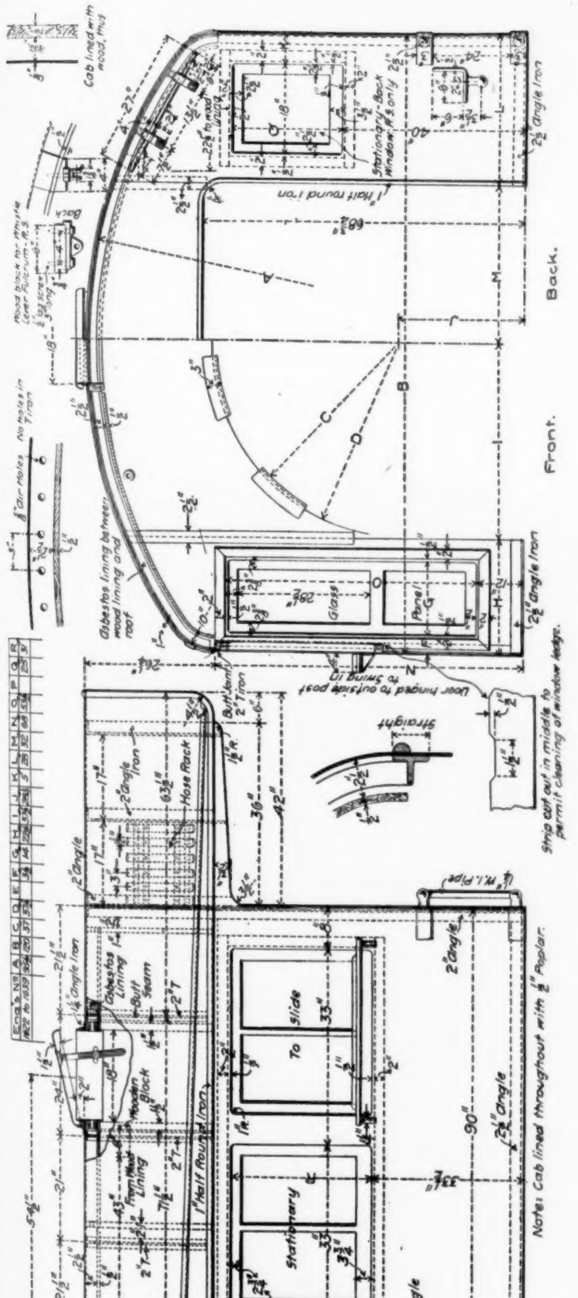


Section E-F.
See engraving below.

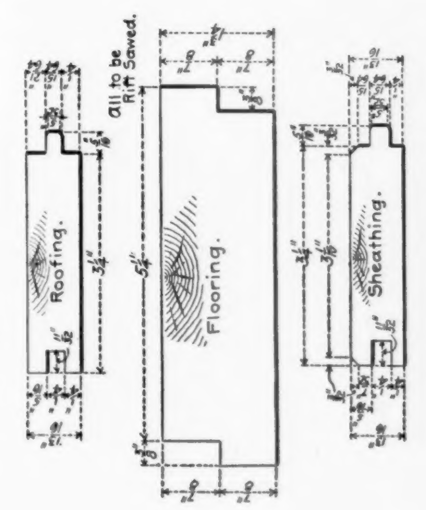




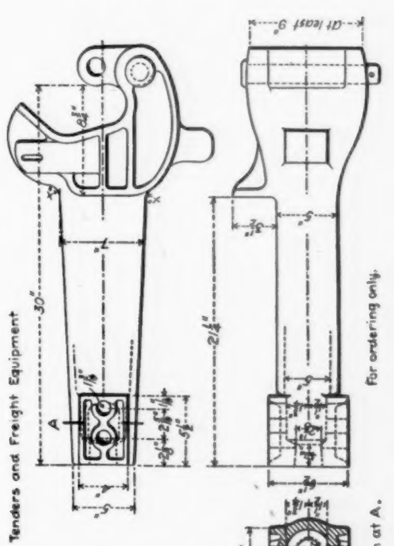
Eccentric Strap



Cab—Sheet Metal, Lined with Wood.



Roofing, Flooring and Sheathing



M. C. B. Coupler—5 by 7-in. Shank

STANDARDS FOR LOCOMOTIVES AND CARS—THE "HARRIMAN LINES."

Union Pacific, Southern Pacific, Oregon Short Line, Oregon Railroad & Navigation Company, Chicago & Alton.

STANDARDS FOR LOCOMOTIVES AND CARS

For "Harriman Lines,"

Union Pacific, Southern Pacific, Oregon Short Line, Oregon Railroad and Navigation Company, and Chicago & Alton.

These railroads, which are associated under one ownership, last July inaugurated a policy in the construction of new rolling stock which appears to be an epoch-making improvement. A centralized authority at once suggested the advisability of adopting uniform practice in the construction of new equipment, so that when locomotives, as well as cars, are interchanged among the lines, there will be no delay or embarrassment in making repairs. The advantage of such a plan from a business—the stockholder's—point of view need no elaboration, for it is clear enough that purchases upon one set of requirements for five roads may be made upon most favorable terms, and a relatively small repair stock will suffice.

Last year the motive power officers of these roads, acting together, planned the broad scheme, the scope of which is outlined here. Such a work is really never completed, but remarkable progress has already been made toward the standardizing of all of the details of cars and of the wearing parts of locomotives which may require repairs at shops of other than those of the road to which the engines are assigned. In the cars, everything except the knuckle-end of the coupler will eventually be standardized. In locomotives, the plan will be carried out with reference to all parts except the design of boilers. This applies only to new equipment, but it is obvious that many of the standard details will be used in repair work wherever they will fit.

Mr. S. Higgins, superintendent of motive power of the Union Pacific, has generously supplied specifications, drawings and books of standards, showing what has been done up to date. These include specifications for material, which all of the purchasing agents will use. Each of the superintendents of motive power has a book of car and another of locomotive standards, in which additions will be made, and as the work proceeds drawings are made to correspond. A sample page from the locomotive book is as follows:

Description.	Drawing.	Reference.
W		
Weights on drivers, pounds............		
Desired on one pair, 45,000............		
Maximum limit, 50,000................		
On two pairs, 90,000.................		
On three pairs, 135,000..............		
On four pairs, 180,000...............		
Wheels, engine truck, all road engines to have steel tires...............		

This sample page shows the starting point with reference to the locomotive standards. Cylinders are designed to keep the ratio of adhesion to tractive power between 4.25 and 4.75, the sizes of cylinders being 19, 20 and 21 ins. in diameter for simple engines, and 14 and 24, 15½ and 26, and 17 and 28 ins. for compounds, the stroke to be made to suit the service and grades. All simple engines will have steam ports 18 ins. long. All cabs will be made of steel, 90 ins. long and 120 ins. wide. Crank pins will be made of one size for each type of locomotive indicated on the drawing.

The selections from the standard drawings already adopted serve to indicate the thoroughness of this work and the lines which are being followed. The ideas and experience of all the officers concerned are obtained at meetings held for the purpose, and while no one road dominates, the details are placed in charge of Mr. Higgins, who is ably assisted by Mr. F. N. Hibbits, mechanical engineer of the Union Pacific.

This interesting and inspiring subject will be placed before the readers of this journal in greater detail next fall. It is to be hoped that this example will attract the attention of other lines having official organizations which will permit of such sensible and altogether economical practice. No more important mechanical policy has ever been introduced upon American railroads. A great opportunity is lost if concentration of ownership of railroads is not followed by a plan in mechanical matters which will eliminate the expensive and unbusinesslike practice of the present, which is due to the different whims and crotchets of several motive power superintendents who are all in the service of the same set of stockholders. There can be no reason why two lines owned by the same people and running over similar profiles between the same terminal cities should not be almost exactly alike. There is no reason why a locomotive which is safe to haul a freight or passenger train into Omaha from the east is not as safe and serviceable to haul it out of the same city to the west. There is no reason why a steel underframe for a box car should not be equally satisfactory for a stock car. Arguments may be multiplied indefinitely to bring out the advantages of standardizing.

The standardizing of equipment is one of the most important questions before the railroads of this country to-day, and other pointed references to the principle will be found in this issue.

PROFESSIONAL SPIRIT IN RAILROAD SERVICE.

By F. A. Delano, General Manager Chicago, Burlington & Quincy Railway.

Editor's Note.—This article was written in response to a special request for the author's views as to the prospects of railroad service for educated young men.

I am frequently asked by young men, or by fathers or friends of young men, what the prospects are for a young man in the railroad business, with special reference to those with pretty fair education who wish to make railroad work their profession.

I have heard it argued that railroad work was not a profession any more than any branch of trade or commerce, but whether this is so or not, I think it is obvious to anyone that a man may go into "railroading" with a professional spirit quite as much as a man may take up art or literature, medicine or law. A profession requires of a man that he should go into the work with heart and soul, and with the desire and intention of doing something worth doing; or, as Ruskin puts it in regard to art, somewhat as follows: A man who devotes himself to art must do it "for art's sake alone," not for the love of gain or prestige or glory, but for the sake of doing something worth doing. Doubtless there are a few men who go into railroading every year with this end in view, and I believe it is obvious that, as the number of men who do so increases, the standard of railroad work will improve.

It may be asked what this notion of railroading has to do with success as a railroad man or the wise operation of the railroad property. To answer this question, I am disposed to go back to the first principles of what every man's aims may properly be. In the words of the Declaration of Independence, every man has "the right to life, liberty, and the pursuit of happiness." The greatest measure of life and liberty comes to those who are thoroughly in earnest about what they are trying to accomplish, to whom work is not a drudgery or daily routine; and we all know that happiness is not measured by position or salary.

It would be a mistake for any man to encourage another to enter railroad work, quite as much as it would be a mistake to encourage him to enter any other profession. The desire to give one's life to any profession must spring from the man himself, and not be forced upon him; but there is much in railroad work which, in the vastness of the field and diversified and absorbing interests, equals that of any other profession.

Let me enumerate a few of the problems which confront the student of railroad questions of to-day, and let me say that

even slight progress along any one of these lines is a worthy achievement for one man:

(1) The development of organization; (2) better co-operation between various co-ordinate departments of a large, complex organization; (3) harmonizing conflicting interests in the relations of railway officers and employees, and between the railway and the public; (4) the economic principles underlying the making of rates; (5) the principles of railway location; (6) the practical limits of expenditure in the reduction of grades and curves; (7) the more thorough combustion of coal and the more complete use of the products of combustion in locomotive and stationary boilers; (8) the more economical use of steam in the locomotive engine; (9) economies in shop management and locomotive and car maintenance; (10) water purification, timber preservation, and many more which might be mentioned.

A young man entering the railway service with such aims as I have outlined, and endowed with a fair amount of courage and persistence, patience and common sense, is certainly quite as sure to make a "success" in the sense of doing something worth doing and of satisfying himself, as in any profession. Large combinations of capital in railroad, as in any other business, have not by any means destroyed a young man's chances. New problems of great importance have been introduced. The work of organization so as to centralize authority, yet place on each part of the machine its proper burden, is very difficult to accomplish. The operation of a large railway, like the operation of any large consolidation of widely-scattered manufacturing plants, or the operation of a large machine consisting of many pulleys or gear wheels for transmitting power, involves serious losses in friction and in the doing of useless work. How to diminish this friction and useless work to a minimum, and do the greatest amount of effective work for the power utilized, is a great problem.

Furthermore, a man entering the railroad service with the object of making it his profession must put to one side any idea of listening to the siren voice of those who seek to tempt him away. Granted that many a doctor, lawyer or minister has had an opportunity to quit his profession and to take up some other pursuit, if he does so his career in the profession he has followed ends; and it is equally true with many of the young men who enter railroad work. The temptation of a little more pay to enter the manufacturing field frequently tempts them away, and they give up the chance of becoming something in the railroad profession.

THE OVERLOADING OF LOCOMOTIVES.

By G. R. Henderson, Superintendent of Motive Power,

Atchison, Topeka & Santa Fe Railway.

The matter of tonnage rating of locomotives is frequently overdone to such an extent that not only is a greatly reduced mileage obtained from the power, but traffic is delayed on account of the slow movement of trains, thus blocking other and more important traffic. The writer remembers an incident on a certain road where a locomotive was calculated to take a load of 610 tons up a 2 per cent. grade, and instructions were issued from the transportation department to give it 850 tons. This load, of course, pulled the engine backward down the mountain. The load was then reduced to 650 tons, when the result was that the trains crawled up the mountain at a speed of about four miles per hour. After working this way for several months, the officers of the operating department, thinking that they had beaten the motive power department in the rating, the loads were reduced to 610 tons, and we understand it has been operated with this load for the last two years. This enabled the trains to climb the mountain with about double the speed and make more trips in a day than with 650 tons, showing that a small margin of 40 tons will make a great difference in the operation of a locomotive on a heavy grade.

Referring to another case which happened within the writer's recent experience: This locomotive, with 52,000 pounds tractive force, was figured to draw 1,100 tons up a grade 124 miles long, with numerous 95 ft. grades in it. When the rating was made 1,150 tons, it was found practically impossible to ascend this grade without doubling at some points and greatly delaying the train. With 1,100 tons the trip was made readily, at a much better speed, showing that in this case a small difference of 50 tons was also accountable for the practical success or failure of this engine.

On a 3 per cent. grade, my calculations showed 600 tons to be the proper rating, yet 700 tons were occasionally applied, with the result that critical points had to be doubled, the engine was very slippery, and delays in handling trains ensued, whereas with 600 tons the engine went up at a good speed, and kept the traffic moving in good shape. Some people would think it incredible that a small difference of 40 or 50 tons would make such a difference to a large engine; but if tonnage rating is correctly figured (and it is a small matter to figure rating on heavy grades), there will be little difficulty in maintaining a proper train movement and getting good results from the power.

Another cause which influences this greatly is the fact that there may often be discrepancies and errors in the profile of the section. It recently came to the writer's knowledge that certain engines were not beginning to pull their tonnage on a certain grade. This grade was stated to be 1.40 per cent. The rating figured for the engines in question was 1,350 tons. It was stated, however, that they found it necessary to reduce the tonnage to about 1,150 tons. This, of course, called for an investigation, and, upon going thoroughly into the matter, it was found that, while the profile showed maximum grades of 1.40 per cent., as a matter of fact there were occasionally stretches of road where the grade ran as high as 1.65, which called for a rating of 1,200 tons. The engine was able to handle this tonnage nicely upon making a trial, and this again demonstrated the necessity for close observation and careful analysis of the various details which go to make up the record in an engine test.

If an engine will not pull a certain tonnage, there may be two or three things about the engine to be looked for.

First—It may be impossible to maintain steam.

Second—Even if steam is maintained, the proper work may not be gotten out of the cylinders.

Third—Internal friction may be such as to greatly reduce the effective drawbar pull. These facts may be determined by means of a steam engine indicator and the dynamometer car, and if the engine is then exerting the calculated drawbar pull, there is no reason why it should be considered as failing in its duty. The fault evidently lies with an incorrect profile or some unusual condition of train friction.

MEETINGS OF DEPARTMENT SUBORDINATES.

By Robert Quayle.

Superintendent of Motive Power, Chicago & Northwestern Railway.

The office of superintendent of motive power is largely executive. It calls upon him and his assistants, including the master mechanics and others, to devise ways and means that will enable him to render the best possible service to the patrons of the railway he serves, and at the same time obtain the best results for the least expense.

It is not possible for one man to be able to grasp the situation in detail on a large railway. There is much information that he must necessarily depend upon his subordinates for; hence the reason that his official associates in the work should be educated thoroughly in the policies to be pursued

by the head of the department; and they should by such education work harmoniously toward the successful attainment of the policies adopted. In adopting such policies, I have considered it wise and beneficial to have them discussed thoroughly by the master mechanics of the railway; hence the reason for the adoption of what we term a local master mechanics' association.

At these meetings, which are held about eight times a year, we discuss important questions and problems pertaining to cost of operation, the improvement of the condition, the betterment of the service, the adoption of standards, the abandonment of expensive methods of doing work, and the introduction of cheaper and at the same time more effective methods of accomplishing the same or better things.

It goes without saying that when ten or a dozen men belonging to one department get together, and they know what subjects are to be discussed at the next meeting thirty days in advance, they begin to prepare themselves, and get such data as will be of value and as will show that they are on the alert and are looking for the successful accomplishment of the subject to be discussed. And this preparation necessary for the discussion of these topics makes them more capable, more efficient, and better all-round men. Every man has a justifiable pride in himself to do just as much as the other fellow can do. We are not all born with the same attainments. Some have larger executive ability than others. One man is a genius, and his forte is particularly adapted to shop practice, devising schemes and "shop kinks" that will enable the company to do its work more quickly and more cheaply in the shops. Another man may not have this mechanical genius, but he may have the ability to foresee things and to forestall trouble, and the ability to have other men in his employ think that he is the best fellow in the world and whatever he does or says is right, and the men are loyal to him and to his interests, and therefore to the company's interests. Thus he is able to marshal his forces and hold them in line and get whatever is right out of them.

There is another class of men able to formulate ways and means for accomplishing certain ends, and they have not the ability to execute and to see that the other men put into execution the schemes that they have devised.

When, however, we get these men all together, and one gives his opinion on his best line of thought, and another on the line of his genius, and another on the line of his great executive ability, and another one on the fact that he is able to compel the other men to execute and to do what he has formulated—each of these men, while listening to the others, gets the best (more or less) of each of the others' spirit, and he sees where he lacks; and therefore, by their association and working together, each man improves himself, and is thereby better fitted, and is made a better all-round man for the work he has to accomplish.

Now, as to the results of this kind of organization:

First, it brings all the heads of the various divisions into close relationship with the head of the department. The head of the department must be liberal and broad in his views. He must not, however, sacrifice any of the company's interests or any of his personality in order to accomplish this. It is not necessary. It is good policy to take a vote on subjects, and allow the majority vote to carry; provided, of course, that the head of the department understands that it will not be in conflict with any policy of the road. When the master mechanics realize that their vote is a factor in the management of the motive power department, it at once not only touches their pride, but causes them to realize that they are not mere machines, but that they at once have become a part of the management of the motive power department, and that therefore they must consider the questions from every standpoint, and be able to vote intelligently, so as to make no mistakes. The other factor is that when these men go back to their respective divisions, and they have become a party to some new method, and it is introduced, it at once commands their attention and their best efforts to make that which they have fathered win.

These meetings promote harmony between the master mechanics, and thus strengthen our entire organization. We arrive at a clearer understanding concerning our methods, and thus save a good deal of time and clerical work. It at once makes a uniform practice in our work, as well as a uniform method of handling our men from one end of the system to the other. It not only introduces, but maintains standards in our shop work, which are of incalculable value to the railroad company. Standards reduce the number of parts carried in stock; they reduce the number of drawings in the drawing office, and in every way are most desirable, as well as economical.

While perhaps it cannot be said that by these practices we maintain a standard of men, we can say that it does raise the standard of our men, and causes each man at the head of the various branches of the mechanical department to pin his standard just a little higher each year. He fixes some ideal in his mind, and he works constantly to maintain that high standard which he has placed before himself as the result of these meetings. It in a manner prevents men from getting into ruts. While it is true that associations or organizations will sometimes get into ruts, it is certainly a fact that where ten or twelve men are assembled together to determine the best practices and the best methods of all kinds to be used, they are much less liable to get into ruts than would a single individual. Therefore, in a word, the railroad company which they serve gets the benefit of the exchange of ideas—the benefit of what a dozen men say as to the best practices on all the other roads they come in touch with, as well as the literature they read, and the pointers they get from each member of the association.

By having a personal discussion of the cost of the amount of coal used per 100 ton miles, the cost of oil, the cost of engine repairs, and the cost and extent of engine failures and their prevention, we at once get to the heart of these subjects, and each man profits by the experience of the others, and this enables him to cull out the poor and select the good, and thereby improve materially the conditions on his division.

TACT IN RAILROAD SERVICE.

By A. M. Waitt,

Superintendent of Motive Power and Rolling Stock, New York Central & Hudson River Railroad.

The fundamental elements of a successful business career have been illustrated by a well-proportioned four-legged chair. Although, by great care, the chair may be made to support its occupant, after a fashion, with one leg missing, yet a successful and complete support is furnished only by the entire four. These supports to a successful career are: Education, Practical Experience, Business Ability and Tact.

Much has been said and written about the first three of these essentials, but less has been said about the last. To be sure a tactful person naturally exercises this attribute without making it noticeable; in fact this feature comprises one of its essential elements.

If we seek a dictionary definition we find it described as "fine perception, a fine sense of how to avoid giving offense, ability to do or say what is best for the intended effect."

A little consideration of these definitions will at once show the importance of such an element in the fully successful business career.

Life is full of hills, which must either be climbed, tunneled or gone around. It has many sharp edges to be passed without getting badly hurt. It has numerous obstacles to success and happiness to be overcome and yet avoid serious falls. The man who has this gift is the one who can surmount or pass these obstructions unscathed. Without tact, even though pos-

sessing a complete outfit of education, experience and business ability, a man will constantly make mistakes through haste, conceit or excessive enthusiasm. These will leave him on the level of the many who do not possess that fineness of discernment and action which gives employers or others in higher authority the confidence to place him in positions where he must cope with the larger general problems, patrons, business solicitors and the general public. These positions require freedom from errors in judgment, or if errors are made they require the ability to minimize their effect.

One essential element of tact is kindness, which always puts one's self in the other's place before passing judgment. This faculty must be in constant action on many occasions, hence it must be well and carefully cultivated. It is not by any means merely an inheritance. It may be developed and strengthened. The tactful person never says an unpleasant thing in a manner to unnecessarily wound the feelings of another. He sugar-coats all bitter pills, and does not tear out an obnoxious growth, but removes it with the surgeon's skill, and then dresses the wound for rapid healing without leaving a scar. He knows, not only when and what to do and say, but equally well when and what not to do or say. One never knows what changes life may have in store. Friends are always blessings, and enemies are always a source of sorrow and annoyance. We should so treat all with whom we come in contact that, whether we can comply with their wishes or not, they still remain our friends and we retain their respect and good will.

When it is necessary to discipline a subordinate it should be done in such a way that he will feel that he has been fairly and honorably treated, and that the discipline was merited. The officer should always praise a good action or faithful effort. He should notice, greet and encourage his subordinates and yet maintain firm discipline and proper dignity. The officer should so act that they will consider him fair, just and reasonable, and will see that he has their best interests at heart. This includes such treatment as to encourage them to do their very best for the interests of their superior and employers. Such a course will enable the officer to make every subordinate feel that the "boss" wants, if possible, to find a better position for every faithful man, and that he knows pretty well what every man is doing. It will enable the head of the department to carry out this principle, which is essential to a strong organization. Strong language, sarcasm or angry words between officers and men will never be used under such conditions. Practice proves that "you can catch more flies with molasses than with vinegar."

Tact is equally necessary in the dealings between the subordinates and superior officers. It will make one careful never to exaggerate reports, either verbal or written. The truthful man will say all the good things possible of others, and not mention or magnify the evil. The subordinate should have freedom, with respect, but not familiarity. When asked for an opinion, it should be given frankly, with the reasons upon which it is based, but opinions should not be urged or pushed if they are not wanted. No word or act should be thought of that may be construed or interpreted as disloyal.

This subject also includes the relations between the officers and supply men. They should always be given a fair hearing and pleasant greeting. Ways may be found for denying a request, for business reasons, without the use of hasty or unkind words. A man who has been "turned down" may yet go away feeling that, even if he cannot secure his object, he is welcomed as a friend or as a visitor.

Our good friends, the supply men, will also permit the suggestion that one soliciting business needs to discern when a railroad officer is busy or perplexed, and this will lead him to be brief or to simply pay his respects and call again at a more propitious time. The wise solicitor will not take undue advantage of those whose offices are conveniently near, to annoy them with too frequent calls, such as regular semi-monthly visits, for frequently such persistency injures rather than helps one's cause. It is always distasteful to hear a competitor "run down" or to hear a "tale of woe," such as is often poured into the ears of a patient railroad man. Tact in both the railroad man and supply man will enable each to so act toward the other that if their positions should ever be reversed each would still be glad to see the other at reasonable times.

On the whole, tact is a wonderfully valuable and necessary feature in enabling one to make his success complete. There is far too little appreciation of the need of its cultivation. Those who do develop it, and use it most, other things being equal, are, as a rule, the most successful, the most highly esteemed and the most truly trusted in matters of great importance.

As a suggestion in the education and preparation of young men for a business or professional career, it seems not amiss to hint that no greater help can be given than by making the necessity of this attribute prominent.

COKE AS LOCOMOTIVE FUEL.

By Henry Bartlett,

Superintendent Motive Power, Boston & Maine Railroad.

After nearly three years' experience, the Boston & Maine Railroad stands as ready to approve the use of coke as a locomotive fuel as at the time your previous article was published on the matter, in your October issue of 1899. The situation has changed somewhat in regard to it, as the consumption has been increased to 160,000 tons annually, and 150 locomotives are using it. It forms at the present time one-sixth of the fuel supply of this road. The above facts would answer alone, perhaps, for the satisfaction it is giving, were not some further information regarding it interesting.

Cast-iron finger grates are now used in all the coke-burning engines, but these have been slightly changed to give more air-space (50 per cent.), which, with the steam jet under them, results in lessening the formation of clinkers. The use of coke is now confined entirely to local passenger and shifting service, and has been discontinued entirely on through passenger service. The reason for the latter was that it was found on long, heavy runs that a deposit formed on the tubes, which, toward the end of the run, partly closed them up and materially affected the steaming qualities of the engine. This deposit was difficult to remove while the engine was working, but was easily taken out when the firebox cooled down. In runs up to 75 miles in length no difficulty is experienced.

No injurious effects are found in any way to the boilers or fireboxes from the use of coke, with the exception of a more rapid deterioration of the pipes, nettings, etc., in the smokeboxes, due to the action of the gases. The same gas also attacks metal superstructures with which it comes in contact, such as bridges and station roofs, but to a lesser degree. To the surprise of all concerned, coke is found to be rather severe on the tenders, the sharp, cutting edges of the fuel rapidly wearing the tank-sheets where it comes into contact with them.

As to the capacity of coke compared with coal, recent experiments show that it appears to correspond closely to that of anthracite coal of similar size and to be about 80 per cent of the capacity of the best coals, such as Pocahontas, Cumberland, New River, etc. By capacity is meant the ability to evaporate steam with a given grate area and draft pressure, irrespective of economy.

The advantages of coke are considered to far outweigh its disadvantages. Under the conditions it is received, it is without doubt one of the most satisfactory fuels for locomotive use, and its appreciation by the traveling public is noticeable in many ways.

VOLUNTARY LOYAL SUPPORT FROM SUBORDINATES.*

By J. F. Deems,

General Superintendent, American Locomotive Company, Schenectady Works.

"How is it that men can be brought into the frame of mind which makes them a part of the company instead of being mere servants."

Your interrogatory certainly touches the question of paramount importance to railroads, as well as many manufacturing concerns to-day, and while I regret my inability to answer your query in anything like the manner its importance deserves, I will venture a few suggestions, based on a good many years' experience in "being handled," as well as in "handling" men.

There can be little doubt that the question of leadership, or the successful management of a large body of men, is largely a question of the personality of the leader, but it would seem that this personality or individuality might be, to a considerable extent, moulded by a careful study of certain basic principles, or cardinal rules concerning the question, and after all that great rule of rules, "Do unto others as you would they should do unto you," is the frame of the entire structure.

It is a question of simple justice; of the proper understanding and application of the broad principles of Right between man and man. No, this is not quite all; there must be a feeling of kinship, a practical recognition and constant exemplification of the universal brotherhood of man; there must be something in common. Oh, but says some one, this will be subversive of all authority; this will be a sacrifice of official dignity. There is no authority worthy the name, except that which secures voluntary service; there is no official dignity except that which is based on the love and respect of the subordinate for the superior, and if the railroads could to-day measure in dollars and cents the exact cost of this so-called "authority" or "official dignity," they would probably find it a liability of much greater magnitude than they now realize.

Again, let men know they are appreciated; impress them with the idea that the success or failure of the company depends largely upon their efforts; this is merely a plain, simple truth. Why should it be withheld?

Then, again, it is probably safe to say that nine out of every ten—yes, ninety-nine out of every hundred—men will work willingly and cheerfully for a less compensation if they are made to feel they are appreciated. This is not suggesting a reduction of salaries, but merely the plain statement of a simple truth. Too much still remains of the old idea that work is a curse, a punishment, instead of being the only real pleasure of life. "There is no pleasure but in resting from work, except resting in work, which is rapture beyond the dreams of sainthood," is a thought it might be well for many men in positions of responsibility to remember, and try and make the work of their subordinates as restful as possible by imbuing their minds with this idea, rather than trying to impress upon them the "official dignity" idea.

"Treat any race, or section of a race, well, and you will improve it. You give it a higher opinion of itself and make it ambitious."

Now, let it be understood that I am advocating no maudlin sentimentalism, no paternalism, nor anything savoring of charity; far from it. It is not these things that men want; but they do believe they are entitled to, and should have recognized, the idea that men are men, and not machines. Let us place the question where it belongs, on a purely commercial basis, and I insist that the methods outlined are those that are attended with the best results for both sides.

The poorest paid and hardest worked men on most railroads are the clerks, and yet their loyalty can be depended on at almost all times, and why? Because they are in closer contact with the heads of departments; because there is that feeling of confidence and mutuality growing out of free and somewhat intimate daily intercourse.

In times of trouble you seldom think of a foreman being disloyal, although he may not be as well paid as some of his subordinates, who are willing to strike on the slightest pretext.

Now, the contention is, that the more nearly the rank and file can be brought into the same influences that surround the foreman or clerks, the more advantageous it will be to the company; and let me suggest here, don't be surprised if many of the efforts to attain this end fail, as it must be borne in mind that we railroad officials have dwelt so long in the high altitude of "official dignity," and left the lower strata, where the rank and file live, so completely to the chronic malcontent, that it will be no easy task to re-educate both sides and get them on a normal basis. But just so sure as these lessons are not learned and advantage taken of them, just so sure is it that the United States will surrender her supremacy as a manufacturing country to a more receptive people, which will be to the detriment of both sides.

Doubtless a multitude of "ifs" and "buts" will be on hand to meet these suggestions, all of which have been indulged in for generations by England, while her lack of receptivity was gradually but surely undermining her supremacy as a manufacturing and commercial nation. Shall history repeat itself in the case of the United States? is a question worth considering.

* Written by Mr. Deems by special request while he was at the head of the motive power department of the Chicago, Burlington & Quincy Railway.—Editor.

REPRESENTATION BY TONNAGE IN THE M. C. B. ASSOCIATION.

By R. P. C. Sanderson, Superintendent Motive Power, Seaboard Air Line.

Among the topical discussions at the last Master Car Builders' Association Convention was the proposal that the voting power of the representative membership be in proportion to the rated tonnage capacity of the cars owned, instead of in proportion to the number of cars owned. The subject was ably presented by Mr. Lentz, of the Lehigh Valley, but the members were evidently not ready to discuss so radical an innovation, and there was no discussion on the subject beyond a motion by Mr. Rhodes to refer the matter to the executive committee for such action as they chose to take. Doubtless the matter will not rest there, but will probably be taken up in many quarters, and whether finally a change in the method of representative voting is made or not it should be well discussed, and it is with this in view that the following notes on the subject are presented.

The main underlying principle from which the suggestion has sprung is that the cost of the modern large capacity cars is so much greater than that of the older 40,000-lb. capacity cars and smaller ones yet, that roads which are destroying old cars and replacing them with new ones of large capacity properly feel that their representative power in the association is being unfairly affected thereby. As an illustration, let us assume that some railroad had, five years ago, 15,000 old 40,000-lb. and 30,000-lb. capacity coal cars, with a total tonnage capacity of, say, 270,000 tons. Let us assume that on account of the heavy cost of maintainance of these old cars in modern heavy service, and to reap the benefit from handling coal in large units, instead of small ones, they decide to buy 10,000 new cars of 80,000 lbs. capacity, spreading the purchase over some years, and retiring the old cars during the same time. At the end of that time they would have increased their tonnage capacity to 400,000 tons from 270,000 tons, largely added to the capital invested in rolling stock, and yet have only ten votes in the association instead of fifteen. Is this right?

As the money invested in the equipment is the principal consideration, it does not look fair, nor is the tonnage basis for representation likely to be any fairer; rather the other way, perhaps. A capacity of 60,000 lbs. is generally considered as large as is practicable, on account of refrigeration, weight, etc., for refrigerator cars. For interchange box cars, a 36-ft. car of 80,000 lbs. capacity will be the general standard for some years to come. Furniture cars are not frequently built of more than 60,000 lbs. capacity, while for hopper cars and gondola cars 100,000 lbs. capacity is already almost a standard. And yet the 15-ton refrigerators cost nearly, if not quite, as much as the 50-ton coal, hopper or gondolas. The 30-ton furniture monstrosity costs as much or more than the 40-ton box car. All of them will cost more than a 50-ton flat car. These differences are going to remain, and would seem to the writer to place a road having a large, expensive equipment of refrigerators, box and furniture cars, at a disadvantage when voting, as compared with a road having less money invested in an equal tonnage capacity of coal cars and lumber flats.

Practically no cars are being built, or will be built, of less than 60,000 lbs. capacity from now on. The old light capacity cars are destroying themselves almost faster than the railroads can stand it, even in prosperous times. Many roads have been forced to take their old cars out of main line service and tear them down as fast as earnings would permit, the expense accounts being charged for replacement, so that a few years will largely wipe out the old car and the possible unfairness due to its having an equal voting value with a modern 50-ton car. This can, therefore, be considered a temporary condition, after the passage of which all the roads will be on an equal footing again; and it is believed that the difference in capacities between refrigerators, furniture cars and coal cars, or ore cars, will be a permanent one, so that unfairness due to a tonnage basis of voting would stay by us.

As the capital invested should be proportionately represented, regardless of the number or capacity or style of car, why not make the voting power proportional to the M. C. B. valuation, new, for cars of all kinds, settling reasonably fair values on such cars in considerable use as are not now included in the M. C. B. price list? Why not have one vote for every $500,000 invested in cars, on the M. C. B. valuation basis?

Before closing the subject for the present, there is another phase of it that should receive attention. It has been contended that cabooses, work train cars, derricks, and cars in freight service that never go off the owners' lines, should not be included in the voting basis, as they are not in interchange service. As far as the cabooses, work train cars, derricks and ditchers are concerned, this objection is a good one; but the total number on any road is so few that there would not be any material difference in the vote if they should all be cut out. But as to coal cars, ore cars, lumber cars, etc., that are often built to run specially between certain points on the owners' roads, these should be included in the vote, for while they are not in interchange service at first, they begin to drift there eventually, due to changes in traffic contracts and conditions. History has proved repeatedly that when cars are built for special service, and have proved themselves economical, the money saved by them is a strong inducement to arrange conditions and facilities so that they can be used in other service, and they soon are found in interchange service. Besides, the M. C. B. standards are used on these cars, the same as others, and should they not be represented when voting for standards of the association?

If, therefore, it is desired to make any change in the voting basis, for the reasons above set forth, the writer would urge that the representative vote should be on the basis of the money invested in freight cars used in revenue freight service, on M. C. B. valuation of cost when new.

DEPARTMENT CONFERENCES.

By T. S. Lloyd,

Superintendent Motive Power and Machinery,

Delaware, Lackawana & Western Railroad.

In the modern organization of the motive power department of a railroad it is essential that the head of the department be in the closest touch with his subordinates. The duties of the executive are becoming more complex on account of new forces being employed and devices hitherto unknown introduced into locomotive performance and shop practice almost daily. Matters of discipline and organization are becoming more intricate, due principally to powerful outside influences, which have manifested themselves to a marked degree, especially in the past two years.

The executive of to-day requires more than technical ability to successfully handle the situation. He must possess other qualifications less easy of estimation than technical proficiency. To correctly appraise the value of a man as a leader of men, and his probable behavior in case of an emergency, frequent personal contact is necessary. It is important that the head of the mechanical department have the master mechanics, mechanical engineer and shop superintendents meet at least once a month; the meetings to be held preferably at the different shops in rotation, when topics, one or more, previously announced for discussion are minutely considered. Interest will be stimulated by the researches of the various officers along these particular lines and opportunity afforded to take up special features of the different shops where the meetings are held. Careful consideration should be given to the opinion of each and criticism freely rendered without offense being taken. Each member should clearly understand that he is an important unit and will voluntarily consider himself as authorized to assist by suggestion and otherwise in the introduction and perpetuation of improvements. Soliciting and obtaining views of the subordinate officers at such conferences also enables the chief of the department to determine the capability and peculiarity of each member of his staff. It enables the latter to absorb from each other and from the chief, modern suggestions, difficult, if not impossible, to obtain in any other manner. It is educational and elevates the personnel, and is worthy of adoption rather than continuing in a primitive way, such as when we never had general conferences or endeavored to obtain in any manner from subordinates valuable features relative to mechanical matters, the adoption of progressive standards and important data pertaining to the economical maintenance of equipment. Such a method discourages the assistant and loss of individuality results. Unless perfect unity and complete harmony prevail the organization is chaotic and necessarily disappointing, regardless of the mechanical ability of the head of the department.

Periodical meetings of the master mechanics and their foremen should be introduced into the individual organization at each shop, the foreman to be requested to suggest plans whereby the production from his department can be hastened and, if possible, cheapened. It familiarizes each foreman with the conditions and requirements of all departments, and methods can be adopted to facilitate the movement of work in such as are backward. The most valuable information can thus be obtained, enabling the master mechanic to be conversant with minute details in every department and to promptly adjust irregularities, if any exist. A feeling of unity and co-operation is produced and a vigorous effort should be manifested by the individual to extend it to the rank and file.

The organization of this scheme is incomplete unless great care is exercised in the selection of a chief clerk or secretary in whom the head of the department has implicit confidence,

He should be of comprehensive mind, familiar with all clerical matters pertaining to the office, and specially trained in the important duty of relieving the executive of trivial routine work. He should be an apt student in mechanical and executive propositions, and having almost constant opportunity for interview should acquire the necessary proficiency to act and execute intelligently, should occasion demand it. He should, when possible, attend the monthly meetings, keeping data of the principal proceedings, such as results of tests conducted and the adoption of progressive ideas in general. By his attendance at the meetings he is familiar with matters discussed and adopted, and his position places him at an advantage where deviation from established practice and methods introduced is quickly observed and brought to the attention of the executive. Unless the chief is so relieved, matters of great importance may escape attention until of such magnitude that they are difficult and expensive to correct.

RATIONAL DESIGN OF LOCOMOTIVE BOILERS.

By D. Van Alstine, Superintendent Motive Power, Chicago Great Western Railway.

The size of a locomotive boiler has an important bearing on the ability of the locomotive to make time, on the consumption of fuel and on the cost of maintenance. The larger the boiler, the more freely the engine will steam when forced to its maximum horse power, the more economical it will be on fuel as compared with a smaller boiler forced to the same horse power, and the lower will be the cost of boiler maintenance because of having to generate less steam per square foot of heating surface. If the maximum tractive power of an engine be referred to its heating surface, and a ratio of 10 to 1 be taken as none too high for an efficient, economical and reliable boiler using western water and coal, then it will be found impossible to get more than three-fourths of the total weight of the engine on the drivers, with weights ordinarily allowed per wheel. The remaining one-fourth will have to be carried on the forward trucks, and perhaps upon trailers also.

The expense of hauling dead weight on engine trucks and trailers need not be a matter of concern, so long as all the weight possible has been put into greater heating surface in the boiler. The value of heating surface is not measured by the maximum number of square feet it is possible to crowd into a boiler, but by the maximum number of properly disposed square feet it is possible to get in.

Good circulation is essential not only to free steaming, but also to reliability and freedom from leaking and cracking. Freedom from leaking and cracking means reduced cost of maintenance. Good circulation is obtained by wide water spaces around the firebox, wide spacing of flues and freedom from sharp bends that impede the flow of the water.

Practically all cases of cracking and leaking are traceable to overheating. Overheating may be due to the collection of scale or to sediment, or to restricted circulation, which prevents water from replacing steam as rapidly as it is generated, or to forcing the boiler beyond its reliable capacity. Water purification, washing out and blowing off, take care of the first cause of overheating, liberal water spaces the second, and ample heating surface the third.

The fuel economy due to ample boiler capacity is probably as great as that due to compound cylinders, and is likely to be more uniform, since the boiler efficiency is only impaire by the gradual accumulation of scale, while the engine efficiency is constantly reduced by blowing piston and cylinder packing and defective valve motion.

It is my opinion that the length of flues and the method of securing them in the flue sheet have little to do with "leaky flues," but that the spacing of flues, length and depth of the firebox and the width of water spaces around the firebox are mainly responsible.

It would seem that with an average evaporation of from 10 or 12 lbs. of water per square foot of heating surface per hour, which must be largely exceeded at the firebox, the flow of steam upward in the water legs must be so great that there is not much downward flow of water, so that the water that gets into the water legs must come from the front through the space between the flue sheet and outer shell. The increased length and decreased depth of fireboxes which are placed on top of the frames, as compared with the old deep and short fireboxes, has increased the demand for water in the water legs and decreased the space through which it is assumed to flow. The head creating this flow has not increased, hence the circulation is not as good, and overheated side sheets result. I have seen in boilers of recent construction the side water spaces so contracted that the rivet heads in seams joining the flue sheet to side sheets and the wagon top to the throat sheet and barrel were only 1½ ins. apart, and they must offer a very material obstruction to the flow of water into the water leg.

The moderately wide fireboxes, such as are used in Prairie type engines, are a decided step in the right direction, not only because of the larger grate area, but because their greater width admits of reducing the length, the firebox side sheets are flat and the water space can be made wide for free circulation.

The extent to which boilers give trouble depends on local conditions surrounding their use, but my observation is that the character of the trouble is the same, and the difference is in degree only. The remedy lies in more rational design.

MODERN CAR DESIGN.

By C. A. Seley, Mechanical Engineer Chicago, Rock Island & Pacific Railway. Formerly of the Norfolk & Western Railway.

The subject of modern car design is not now adequately covered by any standard literature on the subject. By this it is not meant that the railway press has not diligently and faithfully recorded all advances and illustrated the new designs that have been proposed or adopted in American railway practice. Indeed it is only by a close study of the current periodicals which cover the ground of railway practice that one can become thoroughly informed in the state of the art.

It is not intended in this brief article to do more than to touch upon the general principles which seem to be of prime importance in this line of engineering. The subject is one of greatest importance to railway managements, and not until late years has it demanded the intelligent and painstaking efforts of designers who could appreciate the problems in all their bearings.

The money represented in freight car equipment of the average railroad is probably close to three times the amount invested in freight locomotives. This would be a financial reason justifying the expense of time, talent and care in preparation of designs and specifications of cars. These designs should represent cars of highest ratio of paying load to dead weight. This is not only a financial but a transportation question as well, producing the largest returns in revenue with an economy in motive power, train service expense, sidings and car storage facilities.

The designs should also include the use of materials in construction that are now available, such as malleable and steel castings, standard forms of rolled plates, shapes and bars of steel and pressed forms of various kinds, that are standard with manufacturers. Such practice adds a third reason, that of economy of maintenance, to those of finance and operation.

The most successful car designer is one who views the subject from many sides. The bridge engineer needs to study the methods of the car inspector and repairer and the facilities of the repair track before undertaking car designing. Cars have been built that are beautiful examples of the bridge builder's

art, but they do not appeal to the men in any department of a railroad that has actual contact with them. Neither is it true that a man ignorant of the mathematics of the bridge builder can most successfully use the bridge builder's forms of construction and materials in car construction. It is the composite individual who knows what to use and what to cut loose from; who fully appreciates how far a new construction of new materials and new details can be handled with a reasonable modification of maintenance facilities, and who can make headway against the prejudice of those who would thwart progress when he clearly sees an economic advantage in construction or material.

This is the era of heavy tonnage trains and large capacity cars. The giant strides of the Pressed Steel Car Company and the influence of their designs toward decreasing dead weight, and the consequent increase in the percentage of revenue freight carried, mark an epoch in the history of car building.

One would be unwise to say that the fifty-ton car is the limit, although there are signs that we cannot go much further on present lines. Take, for instance, a fifty-ton car, and if a 10 per cent. excess load is allowed, the total live load is 110,000 pounds. Add to this 40,000 pounds for dead weight, and the total for eight wheels to carry is 150,000 pounds, or 18,750 pounds per wheel. There are not many engine drivers as heavily loaded as that, yet we expect a common cast-iron chilled wheel to perform this service.

The engine which may be called the standard freight engine of the Norfolk & Western Railway is a 21 x 30-in. consolidation, whose eight wheels carry 150,000 pounds, the same weight per wheel as those under many fifty-ton cars. It is quite true that many fifty-ton cars do not weigh 40,000 pounds, but they do not weigh so much less as to materially affect the argument. For coal carrying, the weights of various designs of fifty-ton cars runs from 35,000 to 40,000 pounds, and it is believed that the lighter weights than these are of designs that may need strengthening and reinforcing sooner than is desirable. There are ore and other cars for concentrated lading of fifty tons which require less cubical capacity, and therefore can be made of lighter weight than the above figures. Efforts have been made by some to obtain a light weight by making light trucks, but these are almost uniformly unsuccessful.

Now, what are the probabilities in the design of a fifty-ton car? Say it shall carry 110,000 pounds as a maximum, and that the percentage of revenue freight shall be 75. This means that the light weight shall not exceed 36,666 pounds and that the ratio of dead to live load is 33 1-3 per cent. If the trucks are to weigh 15,000 pounds it will leave 21,666 pounds for the body. It is believed that this is feasible, but not in a wooden car; the frame, at least, must be of steel, the castings of malleable, and all members carefully calculated.

In view of the many difficulties in the design and operation of fifty-ton cars, the necessity for strengthening bridges and permanent way of many railroads not now adapted for such wheel loads, and the safer load for the ordinary cast-iron wheel, the prediction is ventured that the forty-ton car will be very generally adopted in the next few years. It is feasible to build forty-ton capacity hoppers or gondolas to carry 88,000 pounds, with a ratio of dead and live weight of 37 per cent., which means 73 per cent. revenue load, or 2 per cent. less than is stated for an ideal fifty-ton car.

I have never been able to understand the necessity for a forty-ton capacity box car, except for the grain-carrying roads, and the advent of fifty-ton capacity cars is a still greater puzzle. I bow, however, to the superior wisdom of the traffic departments, who not only seem to want them, but also succeed in getting them, and stand ready to make any capacity desired.

Owing to the weight of the superstructure, the average design of forty-ton capacity box cars will not carry over 70 per cent. of revenue freight, as a well designed car and trucks to carry 88,000 pounds will weigh in the neighborhood of 37,000 pounds, new. It is possible to reduce this weight somewhat, as has been done in many cases, but they look very much like 60,000-pound boxes on 80,000-pound trucks, and doubtless will do very well in mixed service, as of all cars the box car is most generally loaded below its capacity.

The use of steel in car construction has brought about many changes in the theories of designers. Formerly there was little or no thought of carrying the load except by the under framing. The sides of the car were merely thought of as necessary to retain the load, and the utilization of the sides of gondolas and hoppers, for a through, uninterrupted truss was not taken advantage of until recently.

Indeed, it has been proposed in some designs to transfer most of the weight of the lading between the bolsters to the sides and thence to the outer ends of the bolsters, but it is believed that this is not desirable. The value of center sills for other offices than carrying is lost sight of. With the heavy tonnage trains and great tractive power now employed, it is believed to be necessary and advisable to use heavy center sills and draft gear connections. It has also been proposed to use such heavy center sills that it will be safe to bracket out from them and thereby carry most of the load, but it is not known that this has been employed to any extent, and it would probably make a very heavy car. In steel there are a number of suitable sections of rolled shapes or pressed or built-up sections which may be employed for sills.

In wood construction the center sills may very profitably be heavily reinforced on the under side between the bolsters, so as to minimize the bad effect of underhung draft gear in transmitting heavy buffing stresses. It is also believed to be good practice to truss all sills except the side sills of wooden cars, but that this may be successfully practiced there should be good body bolsters and needle beams, and the side framing should be well designed, in order to support the sides between the bolsters and needle beams. Proper attention is not paid in all cases in locating the truss rods so that, for an equally distributed load, the rods will be uniformly loaded.

The history of the development of the composite cars of the Norfolk & Western is instructive, overthrowing as it does the old theory that the carrying strength of the car must be provided in the under framing. In 1899 this road built 1,000 fifty-ton hopper cars with steel under frames and wooden hoppers. These cars carry 110,000 pounds, and weigh on an average 39,600 pounds after nearly three years' service. This is a ratio of dead weight to paying load of 36 per cent., or a revenue freight load of 73.53 per cent. The following year there were built 500 flat-bottom drop-door gondolas, which were 33 feet long, 8 feet 9½ inches wide, with sides 4 feet 6 inches high. Average coal would load these cars to 88,000 pounds, but as much of the coal handled by the Norfolk & Western exceeds the common average weight of 52 pounds per cubic foot, giving an overload, the cars were stencilled 85,000 pounds, and their average weight is 32,500 pounds. With the customary excess lading, the ratio of dead weight is 34.8 per cent, revenue load 74.2 per cent. Comparing, then, these two cars, it will be seen that, although the latter is of a lighter capacity, it represents a gain of carrying capacity in proportion to the dead weight. This was brought about to some extent by making a steel truss for the side frames. The lining and flooring of the car are of wood. I believe this design of car was the first employing the construction described to be made in any quantity in this or any other country. The car was a complete success from the beginning, and although a radical departure in car construction, no defects have become apparent, and this year the Norfolk & Western are adding to their equipment by purchase and building 2,500 more of these cars, to be made in accordance with the original design. These cars were illustrated in this journal in June, 1899, page 187, and April, 1900, page 100.

The success of these cars proves that it is not necessary to provide the carrying strength entirely in the underframing. They have heavy center sills to withstand the heavy pulling and buffing strains incident to heavy tonnage train service. The sides, while light, are immensely strong vertically, and reasonably so laterally; in fact, were it not necessary to secure lateral strength we could use much lighter members for the side trusses. It is not necessary for me to go into details of the construction of these cars. Last year (1901) it became necessary to add to the road equipment of fifty-ton hopper-cars, and instead of duplicating the four-sill design of 1899, a new design, employing a steel truss side, was made and 900 cars were built (American Engineer, February, 1901, page 43), which at once demonstrated their superiority over the former design by reason of lighter weight and at the same time being stiffer and stauncher in many respects. These cars now stencil 38,000 pounds on the average, which represents a gain in lighter weight of 1,600 pounds less than their predecessors. Their weight represents a dead weight ratio to live load of 34.5 per cent. and a revenue carrying capacity of 74.3 per cent. These cars have heavy center sills, carrying approximately 55 per cent. of the load, while 45 per cent. is carried by the truss sides to the bolster ends. No defects have appeared in this design, and the road is preparing to build 750 more of them in the near future, on the same identical lines of framing. There is also an order for 750 forty-ton hoppers of a similar design, modified for that capacity.

The Norfolk & Western also built some steel frame box cars of forty tons capacity, American Engineer, May, 1902, page 141. This is a new, untried design, and therefore to some extent experimental. They have steel under, side and end frames, up to and including the plates, with the usual wooden flooring, lining, sheathing and roofing. Steel in box car construction is not as interesting as in hoppers and gondolas or flat cars. Much wood must be used for nailing strips for securing lining, sheathing and floor.

I am of the belief that steel in car construction has come to stay; that while education and experience are necessary in all departments of railways to handle these cars; in design, in operation, in wrecking and repairing, yet the American railways are too progressive to neglect an opportunity to use a most valuable material and to lead the world in car construction.

SHOULD RAILROADS DESIGN THEIR OWN LOCOMOTIVES?

By F. F. Gaines.

Mechanical Engineer Lehigh Valley Railroad.

The answer depends largely upon whether or not the railroads have competent mechanical staffs. There are very few roads that either do not have such a staff or at least admit their utility. A discussion of their value is, however, a separate question. Assuming that the majority of railroad companies have a mechanical department, it would seem that they should design their own locomotives, for several reasons. In answering the question in this manner it is not to be inferred that the experience and ideas of the builders are to be ignored, but rather that they are to be consulted on all sides of the question. After such conference and mutual agreement on the leading points of the design the drawings should then be made by the railroad company.

The type of engine and leading dimensions being agreed upon by buyer and builder, it might seem as if the details were of such small importance that the builders could do just as well, or better, than the railroad company; but in the present status of the art it is the care and attention to details that insure an engine of satisfactory and economical design. The builders, while having better facilities for designing, as good, or a better corps of engineers, lack to a large extent the experience and knowledge derived from observation of engines in service and in handling repairs. On the other hand, the mechanical department of a railroad has, or should have, men who are familiar with the conditions at repair shops and the handling of work, as well as knowledge from experience gained by riding on engines, that is to say, service conditions.

Not so very long ago it was customary to purchase engines for general use on all parts of a road, and under these conditions the engines of the same size and class on different roads differed but little. To-day the conditions of service, not only for individual roads, but different divisions of the same road, demand modifications to produce the best results. Under these circumstances it is natural to expect that the mechanical department of the railroad is better prepared, from a close study of all conditions, to meet and provide for these conditions than the builders.

Many roads absorb the output of local mines for fuel, the fuel requiring for suitable combustion special arrangements of grates and amounts of grate area and heating surface. On some roads, where heavy traffic is provided for by extra tracks, low wheeled engines at moderate speeds may prove very satisfactory, while neighboring roads in the same territory may have such traffic conditions that the use of low wheeled engines incapable of high speed would be out of the question.

Some of the reasons why the road should be better posted than the builder on general design having been given, let us look at the details a little. The putting together of a new engine is an entirely different matter from partially taking it apart. The builder puts it together once when building, and the railroad takes more or less of it apart many times. In putting it together the first time, the builder has the opportunity of assembling it in that order which is most convenient; while in repairing, the part that has to be renewed the most frequently is often the most inaccessible; and in many instances the work has to be handled without the accessories of the builder, such as electric cranes, etc. Lack of repair shop experience on the part of the builder is accountable for many detail designs, which if more attention had been given to the question of repairs would have saved time, money and profanity in the shops.

Service conditions frequently require radical modifications to parts that theoretically have a high factor of safety, yet as a matter of fact are proving by their failure that an experience factor is necessary. Some engines turned out by one of the builders recently had side rods that gave a very high factor of safety, but there was no particular spot where on some of the lot the rods had not broken. Another builder saved weight by steel wheel centers of approved design, but service conditions ruled them out by bending and breaking the spokes and crushing the tread between spokes. In another case the main frames of a lot of engines were carried under the cylinders, the builders dropped the cylinders on the frames and the boilers on the cylinders. When in course of time a broken cylinder had to be replaced, it was found that reversing the process was expensive and required considerable time. This could have been avoided if separate front frames had been used. The same engines had piston valves, and to remove them for new packing rings required a drop pit to eliminate the engine truck from the proposition. I have in mind one more instance of a detail design by builders that would have been modified if repair work had been more familiar to them. The furnace bearers, both front and back, were fastened to the outside sheets of the firebox and covered several rows of staybolts, a broken staybolt requiring the removal of a furnace bearer; the pitting between the sheets will also eventually require patching the boiler.

Lack of knowledge of service conditions is likely to result in a bad cab arrangement. There is no investment that will pay a larger dividend than time taken to carefully locate all

accessories in the cab so as to require the minimum attention and effort of the engineer to operate and adjust.

Beginning with the cab itself, it should be as cool as possible in summer, and warm in winter. To protect the feet of the men from the cold; reverse lever openings, cracks in the floor and pipe openings several sizes too large should be covered. Lagging the back head of a large boiler cuts down the temperature several degrees in hot weather and relieves the fireman to that extent, besides saving fuel that would otherwise be lost by radiation. The location of the engineer's brake valve so that he can readily reach and apply it while leaning out of the window contributes to an easy stop at the right place. The location of both injectors in the cab prevents injector failures, as an engineer on a fast line in bad weather does not like to crawl out on the running board to inquire too closely into the whys and wherefores of a sulky injector. Gauge lamps situated so as to illumine lubricators and gauge cocks so that they can readily be seen saves the engineer lighting a torch, or picking up a lantern, at a time when his attention should be diverted as little as possible. Gauge cocks located in the front part of the cab allow escaping steam to be driven toward the engineer, making it difficult for him to see, while it is blown away from him if they are placed in the rear. Provision for the engineer getting at machinery easily for oiling saves time at station stops; as does also a manhole on the tank of such size as to be reached by the crane without stopping the engine on a chalk mark. In order to provide sufficient water capacity many tanks for large engines have a water space under the firing floor. This makes a solid foundation for the fireman to stand on, but unless covered with wood will result in a large fuel loss, as coal intended for the furnace is thrown out between the tank and engine when the fireman slips on the smooth surface. On some of the big engines, with this style of tank, where every scoopful counts, it is discouraging to the fireman when, instead of getting a shovel of coal, his scoop strikes a rivet and flies up. The rivets could be countersunk, but they are not always. It is a great assistance to a fireman to have a design of tank that will deliver all the coal to him at a point not too far distant from the fire door, as it greatly decreases his work. This can be accomplished by sloping the sides of the coal space so that there are no flat surfaces, and it becomes self-clearing. The focus of all the slopes should be as near the firing floor as possible. Aprons arranged to prevent coal working out at the sides between the engine and tender, and to catch and hold the coal that by accident misses the door, have on some classes of engines been known to save a ton of coal in a round trip.

Engines designed with the repair shop constantly in mind save the extra trouble and cost of such designing the first time the engine goes in for light repairs. In fact it is justifiable to go farther and increase the first cost within reasonable limits, if by so doing the difference in the design will admit of more rapid and economical overhauling. Water impurities affect a boiler in as many different ways as there are kinds of water, and frequently require special designing to counteract them. Heavy curvature calls for ample provision against flange and hub wear and a design that will permit of rapid and cheap renewal of worn parts. On some consolidations built for a crooked road cut flanges on the front drivers became serious for a time. By shortening the radius bar several inches and setting in the tire on the front and back pairs of wheels the trouble was almost entirely disposed of.

The foregoing are some of the details frequently overlooked by builders to a certain extent; more so of late years, since the tax on the builders has become greater on account of the unprecedented demand by the roads for more power. One of the most valuable guides in designing comes from the record of failures on existing engines. Many roads have a system whereby all broken parts are reported by blue print sketches, the location of fracture and size of the part being marked on an undimensioned print. When these reports show by their frequency that a certain part of a certain class of engines requires strengthening, steps are taken to do this in a satisfactory manner. This experience gives the motive power officials an idea of practical proportions, and often furnishes coefficients for otherwise rational formulæ. This experience is from the nature of things, to a large extent, denied the builder; who would undoubtedly be very glad to have the information and also to profit by it. These reasons do not in any manner reflect on the credit of the builder, or his sincere desire to produce the very best machine that brains and money can produce; they do, however, indicate why the mechanical officers of a road are, or should be, better prepared to do their own designing.

LOCOMOTIVE TRACTION INCREASERS.

By Edward Grafstrom,

Mechanical Engineer, Atchison, Topeka & Santa Fe Railway.

Necessity is the mother of invention. History tells us that fifty-two years ago Mr. Baldwin took a contract to build two locomotives guaranteed to do certain work, and, finding that he would not come out even in his calculations, he resorted to the traction increaser. The Baldwin Locomotive Works thus became the birthplace of this device. But history also relates that these two engines were failures from an operating point of view, and that this traction increasing encumbrance was soon removed, even at the sacrifice of tractive force.

As time went on and railroads grew the traffic requirements for more powerful locomotives became prevalent. The true relation between boiler capacity and cylinder force not having been thoroughly studied, locomotive cylinders soon outgrew the boilers, and thirty years after its inception Baldwin's old remedy was dug up as a means of correcting over-cylindered locomotives. The crop of traction increasers which then sprang into existence was tried with such varying success that in 1886 the Master Mechanics' Association appointed a committee to investigate the merits of the different devices used up to that time. When this committee reported, the opinion prevailed that the proper function of the traction increaser was that for which it was originally created, namely, to supply additional adhesive weight to over-cylindered engines, but that its sphere of usefulness did not extend to new and well-designed engines, and that the best traction increaser was an ample boiler, together with the sandbox. Henceforth boilers commenced to grow in proportions, and pneumatic sanding arrangements were brought out, until nothing more in either of these lines could be desired.

But history repeats itself. With the advent of the compound locomotive an increased cylinder force has been put within reach of the engineman which surpasses the established relations between the factors that make up the tractive force. The boilers of modern locomotives are as large as space and weight permit, and the compound cylinders are proportionate when used as such. But the augmented cylinder force, when these engines are worked simple, requires an increased weight which would be superfluous and cumbersome while working compound. This condition has again turned constructors' eyes to the traction increaser.

The Santa Fe is at present experimenting with two distinct styles of traction increasers and four styles of compounding, all of which are already familiar to the readers of The American Engineer. The compound systems do not come within the scope of this article, but the experience of that railroad with the two styles of traction increasers is pertinent to the subject at hand.

One of these types of traction increasers now in use on locomotives recently put into service on the Atchison, Topeka & Santa Fe is similar in principle to one described in a previous number of this journal. It is operated by steam from the locomotive boiler and works on the principle of changing the

fulcrums for the equalizers. So far it has only been used for transferring weight from the front truck to the driving wheels to the extent of increasing the adhesive weight by 7,000 pounds. Its application takes place rather suddenly, partaking of the nature of a jerk; the front end of the engine raises about two inches, the frame coming down close to the boxes in the rear, while the driving springs become cocked to one side.

The other traction increaser receives its motive force from the Westinghouse air supply, with which it is connected through the intermission of a special auxiliary reservoir. Its application is so gradual that it is not noticed on the engine. On the Prairie type of engines, upon which it has been installed, it operates both on the front and trailing trucks, relieving both of a load aggregating about 15,000 pounds.

The weight on the driving wheels of these engines is normally 140,000 pounds. When the traction increaser is applied this is raised to 155,000 pounds. The engines have a tractive force of 34,000 pounds when running compound. This gives a coefficient of adhesion of 23 per cent. when the engine is not using the traction increaser. If the engine is operated in simple working, the tractive force becomes 38,000 pounds and the necessary coefficient of adhesion would then be 27 per cent., which is higher than can be counted on with the best sanding apparatus. By the aid of the traction increaser, however, this coefficient is reduced to about 24 per cent., thus bringing it down to normal conditions. From which will be seen that the new field of usefulness of the traction increaser is principally to regulate the adhesion when compound engines are operated in simple working.

The Santa Fe traction increasers are connected up so that they are put into action automatically when the reverse lever is dropped down into the corners, either in forward or backward motion.

The ideal conditions would be, however, to have the traction increaser apply automatically only when the engine is operated as simple and when the lever is in the positions named.

The principal difficulty with the traction increaser on the Santa Fe is that the enginemen are unable to tell whether it is operative and effective or not. One engineer who runs a regularly assigned engine was asked one day how he liked the device. "It is fine," he replied. "I don't often have to use sand when starting, and the engine walks right off with any kind of a train." In looking over the engine it was found that the traction increaser had been cut out for several trips on account of a leaky operating valve without the engineer's knowledge, but he still clung to his belief that the traction increaser had done the work. The trouble is that with a powerful engine the engineman cannot tell whether or not it is the normal weight of the engine or the traction increaser that gives the adhesion, and if the traction increaser is out of order, he has no means of telling it, unless it is entirely "dead." The inspectors in the roundhouse are equally helpless, for many traction increasers require the jar of the engine, while running, to get them started. This does not mean that traction increasers cannot be made as reliable as the airbrakes, for instance, but that they are still in a stage of evolution, although it is their third appearance before the American railroad world.

LARGE MODERN LOCOMOTIVES—REPAIRS AND LOADING.

By William McIntosh,

Superintendent of Motive Power, Central Railroad of New Jersey.

At the April meeting of the New York Railroad Club, Mr. J. N. Barr laid strong emphasis on the necessity that everyone connected with the care and management of modern large locomotives should pay close attention to their inspection and repairs. These suggestions were pertinent and timely, but he did not go far enough; the importance of this should also be understood by the management, and the fact should be brought to its attention that the change from the capacity of the old power to that of the new is not going to prove all clear gain, and that comparisons with the cost of maintenance of the old equipment are not only manifestly misleading and unfair to the motive-power department, but, if pressed too hard, are liable to produce disastrous results in attempts to meet such comparisons. Consider the matter on an avoirdupois basis: The new equipment is double the weight of the old—it is bought and paid for on that basis—and the weight and cost of repair parts is bound to maintain the same ratio. That to handle these parts requires double the force admits of no argument, whether this force be applied in the form of brawn and muscle or through the medium of machinery; they both cost money. More coal and water are required to fill the tank and boiler, and more sand to fill the sandbox; it will take longer to clean or build fires in a firebox with 80 square feet of grate surface than it will one with 25 square feet; it will take longer to wash out the boiler, longer to fill it up, more time to get up steam, more power to turn the table, and so on through the list; yet motive-power departments are gravely asked to explain why the cost of handling and maintaining motive power should be greater than it was a few years ago. Some unsatisfactory records have been shown up for large power under such pressure, combined with pooling, and without the thorough organization required to keep it in order.

Operating officials naturally look for immediate returns from the new equipment, and on a basis of the increase in tractive power, overlooking the fact that much of it is of new design and not yet fully developed; that the evolution process must continue through the all-convincing method of actual trial, and that the men who are to operate these monsters have to learn their trade over again and develop the skill necessary to handle a 3,000-ton train in place of one of 1,200 tons. The engine-handling forces and repair men at terminals must familiarize themselves with the new equipment before they can handle it and turn it out promptly.

Modern engines exerting a 40,000-lb. pull at the drawbar under 200 lbs. steam pressure are veritable battering-rams, and, if neglected, will soon be damaged far beyond the cost required to keep up the running repairs, and a liberal allowance toward keeping up such repairs will pay big interest in the absence of loose frames, broken brasses and the many other demoralizing conditions developing from neglect or false economy in this respect.

It is perhaps not necessary that forces be doubled, but a liberal policy in this connection will reduce the indirect loss due to inefficient motive power, and when the results are measured by tonnage moved—the only equitable basis to work from—good returns from the investment will be apparent.

A word more regarding overloading in some cases. Engines can be loaded beyond the economical basis; for instance, when the hours on the road from this cause are extended beyond good practice a general loss is bound to follow. In the first place, there is but a narrow margin between a train load that the engine has capacity to handle with ease and the few additional cars that overload it. Under first-mentioned conditions there will be a cheerful and united effort on the part of engine and train crews to keep moving, and there will be, as the mariner says, "clear sailing," but when the tonnage taxes the capacity of the locomotive the crews become weary and disheartened from the long hours on the road and the train movements become sluggish. A daily loss of the use of power amounting to 25 per cent. might thus be easily explained, which would hardly be compensated for by the two or three

A TABULAR COMPARISON OF NOTABLE EXAMP

ARRANGED WITH RESPECT TO TOTAL WEIG

PASSENGER LOCOMOTIVES.

Type—Drivers	4-Coupled	6-Coupled	4-Coupled	4-Coupled	4-Coupled	4-Coupled	4-Coupled	4-Coupled	6-Coupled	6-Coupled	6-Coupled	4-Coupled	6-Coupled
Type—Classification	Atlantic	10-wheel	Atlantic	N. West. Atlantic	Cha't'q'a. Atlantic	Atlantic	Cha't'q'a. Atlantic	Atlantic	10-wheel	10-wheel	10-wheel	Cha't'q'a. Atlantic	Prairie
Name of railroad	Atlantic City	Plant System	Wabash	C. & N. W.	B. C. R. & N.	Canadian Pacific	C., R. I. & P.	C. R. R. of N. J.	Great Northern	Illinois Central	L. S. & M. S.	B. R. & P.	L. S. & M. S.
Number or road class	P1-b	119	......	D	77	......	1301	......	150	64	I-1	162	J
Builder	Baldwin	Baldwin	Baldwin	Schenectady	Brooks	Can. Pac. Ry. Co.	Brooks	Baldwin	Brooks	Baldwin	Brooks	Amer. L. Co.	Brooks
Simple or compound	Vauclain Compound	4-cyl. bal. Compound	Simple	Simple	Simple	Vauclain Compound	Simple	Vauclain Compound	Simple	Simple	Simple	Simple	Simple
When built	1898	1902	1898	1900	1900	1899	1901	1899	1898	1901	1899	1902	1901
Weight, engine, total, lbs.	150,400	155,000	157,900	158,000	158,600	162,000	162,000	163,510	166,580	167,000	171,800	173,000	174,500
Weight, on drivers, lbs.	72,500	114,000	83,450	91,000	88,000	82,000	87,000	87,865	130,000	137,040	133,000	99,000	130,000
Weight, on leading truck, lbs.	41,900	41,000	36,600	33,000	35,600	41,000	38,000	41,295	36,580	30,840	38,800	40,000	21,500
Weight, on trailing truck, lbs	36,000	......	37,850	34,000	35,000	39,000	37,000	34,350	......	......	......	34,000	23,000
Weight of tender (loaded), lbs.	100,000	......	92,680	43,200 (empty)	112,000	105,000	110,000	100,900	96,000	116,120	112,000	120,000	124,500
Wheel base, driving, ft. and ins.	7, 3	14, 1	7, 0	7, 0	6, 9	7, 3	7, 0	7, 3	14, 6	13, 6	16, 6	8, 0	14, 0
Wheel base, total, engine, ft. and ins.	26, 7	28, 4	24, 5¾	26, 9	27, 0	25, 11¼	28, 8	26, 7	25, 4	24, 4	27, 4	20, 2	31, 10
Wheel base, total, engine & tender, ft. & ins.	51, 2½	56, 0	49, 3½	54, 8¾	52, 4¾	53, 0¾	53, 7	53, 2	53, 7¼	53, 3	55, 2¼	......	57, 3¼
Driving wheels, diameter, inches	84½	73	73	80	75	84	78½	84¼	63	63	80	72	80
Cylinders, diameter, inches	13 & 22	15 & 25	19	20	19½	13½ & 23	20¼	14 & 24	20	20	20	20¼	20½
Cylinders, stroke, inches	26	26	26	26	26	26	26	26	30	28	28	26	28
Heating surface, firebox, sq. ft.	134	128	200	170.70	155.8	170	189	136	189	135	223	202.3	169.3
Heating surface, arch tubes, sq. ft.	......	......	......	28.27	17	......	......	43	......	......	......	......	20.7
Heating surface, tubes, sq. ft.	1,645	2,665	2,223.27	2,816.91	2,396	2,231	2,617	2,478	2,196.6	2,362.5	2,694	2,805.6	3,172
Heating surface, total, sq. ft.	1,827	2,793	2,436.16	3,015.88	2,568.8	2,401	2,806	2,657	2,385.6	2,497.5	2,917	3,007.9	3,362
Firebox, length, inches	114	131	101½	102⅛	90¼	110	108	114	123	94	121	108	84⅛
Firebox, width, inches	96	59½	42½	65¼	74	42⅝	74	96	41	63½	41	74	83¼
Grate area, sq. ft.	86	27.25	29.92	46.27	46.38	32.25	54.0	76	32.6	33	36.60	54.43	48.6
Boiler, smallest diameter of, inches	58¾	67	62¼	68⅜	64	60¾	66	64	70	66	66	70⅛	66
Boiler, height of center above rail, ft. & ins.	8, 9¼	......	......	9, 1½	9, 2½	8, 10½	9, 7¼	9, 0⅛	8, 9⅜	......	9, 2	9, 7½	9, 2
Tubes, number and diameter in inches	278, 1¾	341, 2	300, 2	338, 2	306, 2	284, 2	322, 2	318, 2	303, 2¼	350, 2	345, 2	336, 2	285, 2¼
Tubes, length, ft. and ins.	13, 0	15, 0	14, 3	16, 0	15, 1	15, 0	15, 7¾	15, 0	13, 10¼	13, 0	15, 0¼	16, 0¼	19, 0
Steam pressure, lbs. per sq. in.	200	200	200	200	200	210	210	200	210	180	210	220	200
Type of boiler	Wootten	Vanderbilt	Extended Wagon top	Straight	Belpaire	Belpaire	Wagon top	Wootten	Player Belpaire	Vanderbilt	Extended Wagon top	Straight Wide box	Wide box Wagon top
Fuel	Anthra. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Buckwheat Ant. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal
Reference in American Engineer and Railroad Journal	Oct., 1898 P. 341	Mar., 1902 P. 72	......	Aug., 1900 P. 237	Dec., 1900 P. 375	......	Apr., 1901 P. 101	......	Oct., 1898 P. 326	June, 1901 P. 205	Nov., 1899 P. 343	Jan., 1902 P. 29	Mar., 1901 P. 69

FREIGHT LOCOMOTIVES.

Type—Drivers	8-Coupled	8-Coupled	6-Coupled	8-Coupled	8-Coupled	8-Coupled	6-Coupled	8-Coupled	8-Coupled	8-Coupled	8-Coupled	8-Coupled	10-Coupled
Type—Classification	Consolidation	Consolidation	Prairie	Consolidation (with trailer)	Consolidation	Mastodon	Prairie	Mastodon	Consolidation	Consolidation	Consolidation	Consolidation	Decapod
Name of railroad	L. S. & M. S.	D. & H.	C., B. & Q.	Mex. Cent.	R. G. W.	C. & E. I	Chicago Gr. West.	Southern Pac.	N. Y. C. & H. R.	P. R. R.	Lehigh Val.	Northern Pac.	Erie R. R.
Number or road class	B-1	349	R-2	207	300	145	264	2026	G-2	H-6a	10-E-17-W 56-28	Y-2	J-1
Builder	Brooks	Schenectady	Baldwin	Brooks	Richmond	Pittsburg	Amer. L. Co.	Schenectady	Schenectady	Pa. R. R. Co.	Baldwin	Amer. L. Co.	Baldwin
When built	1900	1899	1901	1897	1900	1899	1902	1898	1901	1899	1899	1901	....
Simple or compound	Simple	Simple	Vauclain Compound	Simple	Simple	2-Cylinder Compound	Tandem Compound	2-Cylinder Compound	2-Cylinder Compound	Simple	Vauclain Compound	Tandem Compound	Vauclain Compound
Weight, engine—total, lbs.	174,000	176,000	176,192	193,450	183,000	185,950	191,700	192,000	192,000	193,500	195,000	198,000	200,550
Weight on drivers, lbs.	154,000	157,500	132,838	145,200	166,400	146,950	133,200	155,000	166,000	173,900	171,000	175,000	173,700
Weight on leading truck, lbs.	20,000	18,500	17,034	23,450	16,600	39,000	28,400	37,000	26,000	20,500	24,000	23,000	26,850
Weight on trailing truck, lbs.	....	....	26,320	24,800	....	....	30,100	....	....	....	....	....	....
Weight on tender (loaded), lbs.	124,500	102,150	116,600	93,300	106,000	100,000	120,000	39,650 (empty)	108,500	134,700	121,000	47,000 (empty)	90,100
Wheel-base, driving, ft. and ins.	17, 4	17, 8	12,1	15, 0	16, 8	15, 6	11, 4	15, 6	19, 0	16, 6½	16, 3	17, 0	18, 10
Wheel-base, engine, ft. and ins.	25, 6	24, 5	28, 0	23, 5	24, 11	26, 2	29, 2	26, 5	25, 11	24, 9	25, 5	26, 2	27, 3
Wheel-base, total engine & tender, ft. & ins.	55, 4¼	51, 1¾	54, 5½	50, 9¼	52, 11	54, 6½	54, 2½	53, 6½	53, 10	58, 1½	52, 6⅝	53, 10½	53, 0½
Diameter of drivers, inches	62	50	64	56	56	54	63	55	63	56	62	63	50
Cylinders diameter, inches	21	22	16 & 27	21	22	21½ & 33	16 & 28	23 & 35	23 & 35	22	17 & 28	15 & 28	16 & 27
Cylinders, stroke, inches	30	28	24	26	28	30	28	32	34	28	30	34	28
Heating surface, firebox, sq. ft.	199	225.53	151.1	224	206	197	179	206.5	155.4	166.5	177.7	155.64	185
Heating surface, arch tubes, sq. ft.	22.3	86.75	22.5	....	....	....	....	....	27.09	....	....	26.43	....
Heating surface, tubes, sq. ft.	2,653	3,036.26	2,733.0	2,175	2,667	2,044.8	3,071	2,819.3	3,298.08	2,675.9	2,809.6	3,231.9	2,228
Heating surface, total, sq. ft.	2,874.3	3,348.54	2,906.6	2,399	2,873	2,241.8	3,250	3,025.85	3,480.57	2,842.4	2,987.3	3,414.	2,470
Firebox, length, inches	120¼	120	84	120	122	126	96	120	96	107	118	100 1-16	131½
Firebox, width, inches	40¼	108	72	37¾	41 1-16	41	74	42	75⅜	66	96	75¼	98⅛
Grate area, sq. ft.	33.5	90.19	42	31	34.7	35.8	48.5	35	50.32	49.1	76.33	52.29	89.0
Boiler, smallest diameter of, inches	68⅜	74	65¼	74	74	64	70⅛	72	70⅝	69½	66	66½	76
Boiler, height of center above rail, ft. & ins.	9, 4⅛	8, 7	8, 0	9, 1	8, 7	8, 7	8, 8	....	9, 7	9, 2	8, 10¼	9, 5	8, 0
Tubes, number and diameter in inches	340, 2	417, 2	272, 2¼	374, 2	318, 2¼	288, 2	352, 2	332, 2¼	396, 2	373, 2	358, 2	388, 2	354, 2
Tubes, length, ft. and ins.	15, 0⅛	14, 0	17, 1 11-16	11, 1 5-16	14, 2⅞	13, 6	16, 8⅞	14, 6	16, 0	13, 8½	15, 1	16, 0	12, 0¼
Steam pressure, lbs. per sq. in.	200	180	200	180	190	200	200	200	210	205	200	210	180
Type of boiler	Wagon top	Wide Firebox	Wide Firebox	Belpaire	Extended Wagon top	Extended Wagon top	Wagon top	Extended Wagon top	Wide Firebox	Belpaire Wide Firebox	Wide Firebox	Wide Firebox	Wide Firebox
Fuel	Bitum. Coal	Anthra. Coal	Bitum. Coal	Wood and Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Anthra. Coal	Bitum. Coal	....
Reference in American Engineer and Railroad Journal	Feb., 1900 P. 37	Dec., 1899 P. 398	May, 1901 P. 135	Nov., 1897 P. 371	Sept., 1900 P. 283	Mar 1900 P. 84	Apr., 1902 P. 123	Jan., 1899 P. 26	Mar., 1901 P. 83	June, 1899 P. 177	Apr., 1899 P. 110	Sept., 1901 P. 271	....

NOTE—These figures have been verified by the railroad officials in charge.

R COMPARISON OF NOTABLE EXAMPLES OF RECENT

ARRANGED WITH RESPECT TO TOTAL WEIGHTS.

PASSENGER LOCOMOTIVES.

upled 't'q'a. antic	4-Coupled Atlantic	4-Coupled Cha't'q'a. Atlantic	4-Coupled Atlantic	6-Coupled 10-wheel	6-Coupled 10-wheel	6-Coupled 10-wheel	4-Coupled Cha't'q'a. Atlantic	6-Coupled Prairie	6-Coupled 10-wheel	6-Coupled 10-wheel	4-Coupled Central Atlantic	4-Coupl Atlanti
C. R. N.	Canadian Pacific	C., R. I. & P.	C. R. R. of N. J.	Great Northern	Illinois Central	L. S. & M. S.	B. R. & P.	L. S. & M. S.	N.Y. C. & H. R.	A., T. & S. F.	N. Y. C. & H. R.	P. R. R
7	......	1301	......	150	64	I-1	162	J	F-3	T-14-B	I-2980	E-2
ooks	Can. Pac. Ry. Co.	Brooks	Baldwin	Brooks	Baldwin	Brooks	Amer. L. Co.	Brooks	Schenectady	Baldwin	Schenectady	P. R. R Co.
nple	Vauclain Compound	Simple	Vauclain Compound	Simple	Simple	Simple	Simple	Simple	Simple	Vauclain Compound	Simple	Simple
00	1899	1901	1899	1898	1901	1899	1902	1901	1900	1901	1901	1901
,600	162,000	162,000	163,510	166,580	167,000	171,800	173,000	174,500	175,000	175,000	176,000	176,60
000	82,000	87,000	87,865	130,000	137,040	133,000	99,000	130,000	134,200	135,000	94,800	109,03
600	41,000	38,000	41,295	36,580	30,840	38,800	40,000	21,500	40,800	40,000	42,600	36,650
000	39,000	37,000	34,350	......	......	......	34,000	23,000	......	......	38,600	30,917
,000	105,000	110,000	100,900	96,000	116,120	112,000	120,000	124,500	112,000	110,000	112,000	90,000
, 9	7, 3	7, 0	7, 3	14, 6	13, 6	16, 6	8, 0	14, 0	14, 11	14, 6	7, 0	7, 5
, 0	25, 11¼	28, 8	26, 7	25, 4	24, 4	27, 4	20, 2	31, 10	26, 0	26, 7	27, 3	30, 9½
4¾	53, 0¾	53, 7	53, 2	53, 7¼	53, 3	55, 2¼	......	57, 3¼	52, 11½	56, 6¾	53, 0	60, 113-
5	84	78½	84¼	63	63	80	72	80	75	69	79	80
½	13½ & 23	20¼	14 & 24	20	20	20	20¼	20½	20	15½ & 26	21	20½
6	26	26	26	30	28	28	26	28	28	28	26	26
5.8	170	189	136	189	135	223	202.3	169.3	185.64	182	180	166
7	......	......	43	......	......	......	......	20.7	......	......	27.09	......
96	2,231	2,617	2,478	2,196.6	2,362.5	2,694	2,805.6	3,172	2,729.6	2,811	3,298.08	2,474
68.8	2,401	2,806	2,657	2,385.6	2,497.5	2,917	3,007.9	3,362	2,915.24	2,993	3,505.17	2,640
¼	110	108	114	123	94	121	108	84⅛	108⅛	133½	96⅛	72
4	42⅝	74	96	41	63½	41	74	83¼	40¾	59	75⅝	111
.38	32.25	54.0	76	32.6	33	36.60	54.43	48.6	30.3	......	50.32	55.5
4	60¾	66	64	70	66	66	70⅛	66	66	66	72	65
2½	8, 10½	9, 7¼	9, 0⅛	8, 9⅜	......	9, 2	9, 7½	9, 2	8, 10⅝	9, 2	9, 3	9, 3 5-1
, 2	284, 2	322, 2	318, 2	303, 2¼	350, 2	345, 2	336, 2	285, 2¼	366, 2	360, 2	396, 2	315, 2
, 1	15, 0	15, 7¾	15, 0	13, 10¼	13, 0	15, 0¼	16, 0¼	19, 0	14, 10	15, 0	16, 0	15, 0
00	210	210	200	210	180	210	220	200	200	200	200	205
aire	Belpaire	Wagon top	Wootten	Player Belpaire	Vanderbilt	Extended Wagon top	Straight Wide box	Wide box Wagon top	Extended Wagon top	Vanderbilt	Wide box	Straigh Wide b
um. al	Bitum. Coal	Bitum. Coa.	Buckwheat Ant. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Crude Petrol.	Bitum. Coal	Bit. & Ar Coal
1900	......	Apr., 1901	......	Oct., 1898	June, 1901	Nov., 1899	Jan., 1902	Mar., 1901	Aug., 1899	Dec., 1901	Feb., 1901	June, 19
375	......	P. 101	......	P. 326	P. 205	P. 343	P. 29	P. 69	P. 255	P. 374	P. 35	P. 188

FREIGHT LOCOMOTIVES.

upled soli- ion	8-Coupled Mastodon	6-Coupled Prairie	8-Coupled Mastodon	8-Coupled Consolidation	8-Coupled Consolidation	8-Coupled Consolidation	8-Coupled Consolidation	10-Coupled Decapod	8-Coupled Consolidation	8-Coupled Consolidation	8-Coupled Mastodon	8-Couple Consoli- dation
G. W.	C. & E. I	Chicago Gr. West.	Southern Pac.	N. Y. C. & H. R.	P. R. R.	Lehigh Val.	Northern Pac.	Erie R. R.	A., T. & S. F.	Ill. Central	D., L. & W.	Norther Pac.
00	145	264	2026	G-2	H-6a	10-E-17-W 56-28	Y-2	J-1	836	639	808	Y-3
mond	Pittsburg	Amer. L. Co.	Schenectady	Schenectady	Pa. R. R. Co.	Baldwin	Amer. L. Co.	Baldwin	Amer. L. Co.	Rogers	Brooks	Amer. L. Co
900	1899	1902	1898	1901	1899	1899	1901	......	1902	1899	1899	1901
mple	2-Cylinder Compound	Tandem Compound	2-Cylinder Compound	2-Cylinder Compound	Simple	Vauclain Compound	Tandem Compound	Vauclain Compound	Tandem Compound	Simple	Simple	Tandem Compou
,000	185,950	191,700	192,000	192,000	193,500	195,000	198,000	200,550	201,000	203,000	205,000	209,50
,400	146,950	133,200	155,000	166,000	173,900	171,000	175,000	173,700	176,000	184,800	166,000	185,50
,600	39,000	28,400	37,000	26,000	20,500	24,000	23,000	26,850	25,000	18,200	39,000	24,000
......	......	30,100	......	......	......	......	......	......	......	......	......	......
,000	100,000	120,000	39,650 (empty)	108,500	134,700	121,000	47,000 (empty)	90,100	46,400 (empty)	147,600	106,600	47,000 (empty)
6, 8	15, 6	11, 4	15, 6	19, 0	16, 6½	16, 3	17, 0	18, 10	15, 4	16, 3	15, 0	15, 0
, 11	26, 2	29, 2	26, 5	25, 11	24, 9	25, 5	26, 2	27, 3	24, 1	24, 5	25, 9	23, 8
, 11	54, 6½	54, 2½	53, 6½	53, 10	58, 1½	52, 6⅜	53, 10½	53, 5½	......	56, 10½	50, 4¼	52, 4½
56	54	63	55	63	56	62	63	50	57	57	54	55
22	21½ & 33	16 & 28	23 & 35	23 & 35	22	17 & 28	15 & 28	16 & 27	18 & 28	23	21	15 & 2
28	30	28	32	34	28	30	34	28	32	30	32	34
06	197	179	206.5	155.4	166.5	177.7	155.64	185	178	221	218	173
......	......	......	......	27.09	......	......	26.43	......	......	......	......	22.9
667	2,044.8	3,071	2,819.3	3,298.08	2,675.9	2,809.6	3,231.9	2,228	2,787	2,982	2,950	3,450.
873	2,241.8	3,250	3,025.85	3,480.57	2,842.4	2,987.3	3,414.	2,470	2,965	3,203	3,168	3,646.
22	126	96	120	96	107	118	100 1-16	131½	101⅛	132	123	100 1-1
1-16	41	74	42	75⅝	66	96	75¼	98⅛	71¼	42	97	75¼
4.7	35.8	48.5	35	50.32	49.1	76.33	52.29	89.0	50	38.5	82.4	52.3
74	64	70⅛	72	70⅝	69½	66	66½	76	68	79¾	83⅞	74¾
, 7	8, 7	8, 8	......	9, 7	9, 2	8, 10¼	9, 5	8, 0	......	9, 2	9, 2½	9, 3¼
, 2¼	288, 2	352, 2	332, 2¼	396, 2	373, 2	358, 2	388, 2	354, 2	355, 2	417, 2	410, 2	442, 2
2⅞	13, 6	16, 8⅞	14, 6	16, 0	13, 8½	15, 1	16, 0	12, 0¼	15, 0	13, 8	13, 10¼	15, 0
90	200	200	200	210	205	200	210	180	210	210	200	210
ended on top	Extended Wagon top	Wagon top	Extended Wagon top	Wide Firebox	Belpaire Wide Firebox	Wide Firebox	Wide Firebox	Wide Firebox	Extended Wagon top Wide Firebox	Belpaire	Conical Con. Wagon top	Wide Firebo
tum. oal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Anthra. Coal	Bitum. Coal	......	Bitum. Coal	Bitum. Coal	Fine Ant. Coal	Bitum Coal
, 1900	Mar 1900	Apr., 1902	Jan., 1899	Mar., 1901	June, 1899	Apr., 1899	Sept., 1901	......	June, 1902	Jan., 1900	Nov., 1899	......
283	P. 84	P. 123	P. 26	P. 83	P. 177	P. 110	P. 271	......	P. 179	P. 13	P. 365	......

e.

ENT LOCOMOTIVES.

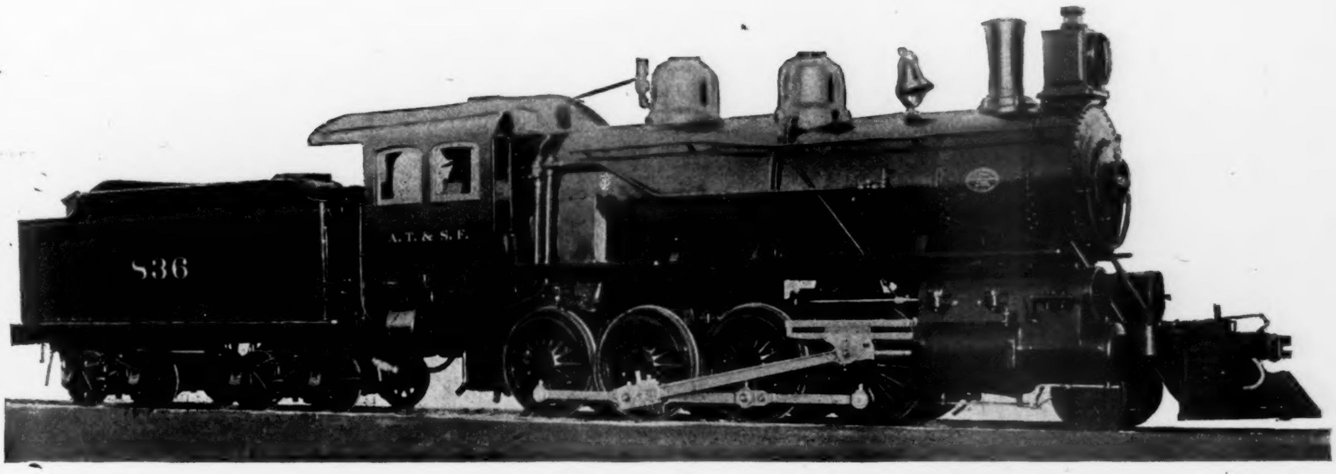
4-Coupled Atlantic	6-Coupled 10-wheel	4-Coupled Atlantic	6-Coupled 10-wheel	4-Coupled Atlantic	6-Coupled 10-wheel	4-Coupled Cha't'q'a. Atlantic	6-Coupled 10-wheel	6-Coupled Prairie	6-Coupled Special Suburban
P. R. R.	D., L. & W.	C., M. & St. P.	Northern Pacific	C., B. & Q.	Union Pacific	C. R. R. of N. J.	Lehigh Valley	A., T. & S. F.	N.Y. C. & H. R.
E-2	1005	A-2	S-2	1586	1820	590	10-D-17-W 66-28	P-14-A	1410
P. R. R. Co.	Brooks	Baldwin	Schenectady	Baldwin	Baldwin	Amer. L. Co.	Baldwin	Baldwin	Amer. L. Co.
Simple	Simple	Vauclain Compound	2-cylinder Compound	Vauclain Compound	Vauclain Compound	Simple	Vauclain Compound	Vauclain Compound	Simple
1901	1900	1901	1900	1902	1901	1901	1900	1901	1902
176,600	179,000	181,535	182,500	183,080	184,240	191,000	194,758	210,800	216,000
109,033	137,000	100,335	141,000	95,880	142,440	99,400	141,348	143,600	128,000
36,650	42,000	45,100	41,500	47,000	41,800	48,000	53,410	29,700	......
30,917	......	36,100	......	40,200	......	43,600	......	37,500	......
90,000	106,000	120,000	42,700 (empty)	......	......	124,000	96,500	112,600	......
7, 5	14, 0	7, 3	14, 10	7, 3	14, 6	7, 8	13, 0	13, 8	15, 0
30, 9½	25, 3	27, 11½	25, 10½	27, 8	26, 9	29, 10	25, 3½	32, 2	35, 9
60, 1 13-16	50, 10¼	57, 5½	53, 7	56, 0	54, 0	53, 8	52, 6⅞	57, 8¾	35, 9
80	69⅝	84	63	84¼	72	85	72	79	63
20½	20	15 & 25	22 & 34	15 & 25	15½ & 26	20½	17 & 28	17 & 28	20
26	28	28	30	26	28	26	26	28	24
166	180	207	208.7	155.5	186	174	171.71	195	162
......	......	......	28.95	......	......	......	......	......	......
2,474	2,520	3,008	2,771.2	2,834.5	2,825	2,793	2,536.59	3,543	2,275
2,640	2,700	3,215	3,008.85	2,990	3,011	2,967	2,708.3	3,738	2,437
72	97	102	120 3-16	96⅛	118 3-16	123	114	108	93
111	127	65⅞	41	66⅛	39⅛	97	89⅞	71¼	97⅞
55.5	82.2	46.76	34.22	44.25	32	82	71.25	53.5	62.07
65	72⅛	66	70	64	66	68	64	70	70
9, 3 5-16	9, 6	9, 5½	8, 9	......	......	9, 8½	9, 2	9, 4	9, 2 1-16
315, 2	350, 2	350, 2	376, 2	330, 2	350, 2	325,2	325,2	318, 2¼	365, 2
15, 0	13, 10¼	16, 6	14, 2	16, 6	15,6	16, 6¼	15, 0	19, 0	12, 0
205	210	200	200	210	200	210	200	200	200
Straight Wide box	Wagon top	Extended Wagon top	Extended Wagon top	Extended Wagon top	Extended Wagon top	Wagon top	Wide box	Straight top	Straight Wide box
Bit. & Ant. Coal	Fine Ant. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Bitum. Coal	Fine Ant. Coal	Anthra. Coal	Bitum. Coal	Anthra. Coal
June, 1902 P. 188	Sep., 1900 P. 272	Oct., 1901 P. 313	....	Apr., 1902 P. 119	Feb., 1901 P. 54	Jan., 1902 P. 15	Oct., 1900 P. 312	Dec., 1901 P. 373	Apr., 1902 P. 115

8-Coupled Consolidation	10-Coupled Decapod	8-Coupled Mastodon	8-Coupled Consolidation	8-Coupled Mastodon	8-Coupled Consolidation	8-Coupled Consolidation	8-Coupled Consolidation	10-Coupled Decapod	10-Coupled Decapod
Northern Pac.	M., St. P. & S. S. M.	Great Northern	A., T. & S. F.	Ill. Central	Lehigh Val	Union	B. & L. E.	A., T. & S. F.	A., T. & S. F.
Y-3	600	100	824	640	:0-E-18-W 49-30	95	150	989	940
Amer. L. Co.	Baldwin	Brooks	Baldwin	Brooks	Baldwin	Pittsburg	Pittsburg	Amer. L. Co.	Baldwin
1901	1900	1898	1902	1899	1898	1898	1900	1902	1902
Tandem Compound	Vauclain Compound	Simple	Vauclain Compound	Simple	Vauclain Compound	Simple	Simple	Tandem Compound	Tandem Compound
209,500	210,000	212,750	214,600	221,450	225,082	230,000	250,300	259,800	267,800
185,500	185,100	172,000	191,400	181,400	202,232	208,000	225,200	232,000	237,800
24,000	24,900	40,750	23,200	40,050	22,850	22,000	25,100	27,800	30,000
....	....	....	....	....	....	....	....	....	....
47,000 (empty)	124,550	96,000	110,000	147,600	121,000	104,000	141,100	134,900	....
15, 0	19, 4	15, 10	15, 4	15, 9	15, 0	15, 7	15, 7	20, 0	20, 4
23, 8	28, 0	26, 8	24, 6	26, 6	23, 10	24, 0	24, 4	28, 11	29, 10
52, 4½	58, 3	53, 11	54, 2¾	60, 2½	55, 0½	54, 9½	57, 11¾	62, 0	59, 6
55	55	55	57	57	55	54	54	57	57
15 & 28	17 & 28	21	17 & 28	23	18 & 30	23	24	17½ & 30	19 & 32
34	32	34	32	30	30	32	32	32	32
173	201	235	165	263	215	205	241	205.4	210.3
22.9	....	....	....	....	....	....	....	....	23.9
3,450.4	2,799	2,730	4,031	3,237	3,890.6	3,116.5	3,564	4,476.5	5,155.8
3,646.3	3,000	2,965	4,266	3,500	4,105.6	3,321.5	3,805	4,681.9	5,390.
100 1-16	132	123	84	132	120	120	132	108 1-16	108
75¼	41	39¾	28-diam. (3-cy'n'd'l) oil br. only	41¼	108	40½	40¼	79¼	78
52.3	37.5	34		37.5	90	33.5	36.8	59.5	58.5
74¾	68	78	74	80⅛	80	80	84	78¾	78¾
9, 3¼	8, 11	9, 5	9, 2	9, 8	8, 7¾	9, 3¾	9, 11¾	....	....
442, 2	344, 2	376, 2¼	652, 1¾	424, 2	511, 2	355, 2¼	406, 2¼	413, 2¼	463, 2¼
15, 0	15, 7	13, 10⅝	13, 7	14, 8⅝	14, 7¾	15, 0	15, 0	18, 6	19, 0
210	215	210	210	210	200	200	220	225	225
Wide Firebox	Extended Wagon top	Belpaire Wagon Top	Extended Wagon top	Belpaire	Wootten	Straight	Straight	Extended Wagon top Wide Firebox	Extended Wagon top Wide Box
Bitum. Coal	Bitum. Coal	Bitum. Coal	Crude Petroleum	Bitum. Coal	Anthra. Coal	Bitum. Coal	Bitum. Coal	Crude oil and Bitum. Coal.	Bitum. Coal
....	Oct., 1900 P. 319	Jan., 1898 P. 1	Jan., 1902 P. 10	Oct., 1899 P. 315	Dec., 1898 P. 395	Nov., 1898 P. 365	July, 1900 P. 214	Feb., 1902 P. 38	June, 1902 P. 192

per cent. of lading that constituted the overload. The efficiency of the crews would be greatly lowered under such a system, assuming that, like the locomotives, they were on the road 25 per cent. beyond normal practice. An additional force, to that extent, would be required, while the overtime paid for the extra hours on duty could easily absorb the gain from the small portion of the tonnage constituting the overload.

The greatest economy with modern equipment and the best all-around results must come from a tonnage well within the capacity of the locomotive and the movement made as near continuous as possible. Toward this end it is not unlikely that track tanks and water scoops will become the rule instead of the exception, and that tonnage trains will be moved with the regularity of passenger trains in the near future. Certainly the proposition is a tenable one, and will appeal from a business standpoint—compare it, for instance, with a factory. The greatest output is obtained in a factory with machinery speeded up to the economical limit, and then run continuously. The same is true of train movements; the ideal results would follow from starting a full-tonnage train and running it to destination at a uniform rate of speed without stopping. Every stop involves not only the time standing, but the time lost in bringing the train to a stand and getting it under way again, besides the wear and tear and liability of pulling out drawbars and breaking knuckles—an indeterminate though not inconsiderable amount.

If tonnage trains could be moved along at an average of ten miles per hour it might be considered satisfactory to all concerned, and it would seem that this movement could be obtained under a thorough organization, especially on double track roads, and under conditions following the lowering of grades and introduction of heavier rolling stock. This continuous movement must be looked to for rounding out the greatest economy of transportation.



Tandem Compound Consolidation Freight Locomotive—Atchison, Topeka & Santa Fe Railway

G. R. HENDERSON, *Superintendent Motive Power*. AMERICAN LOCOMOTIVE COMPANY, *Builders*

TANDEM COMPOUND CONSOLIDATION FREIGHT LOCOMOTIVE.

Atchison, Topeka & Santa Fe Railway.

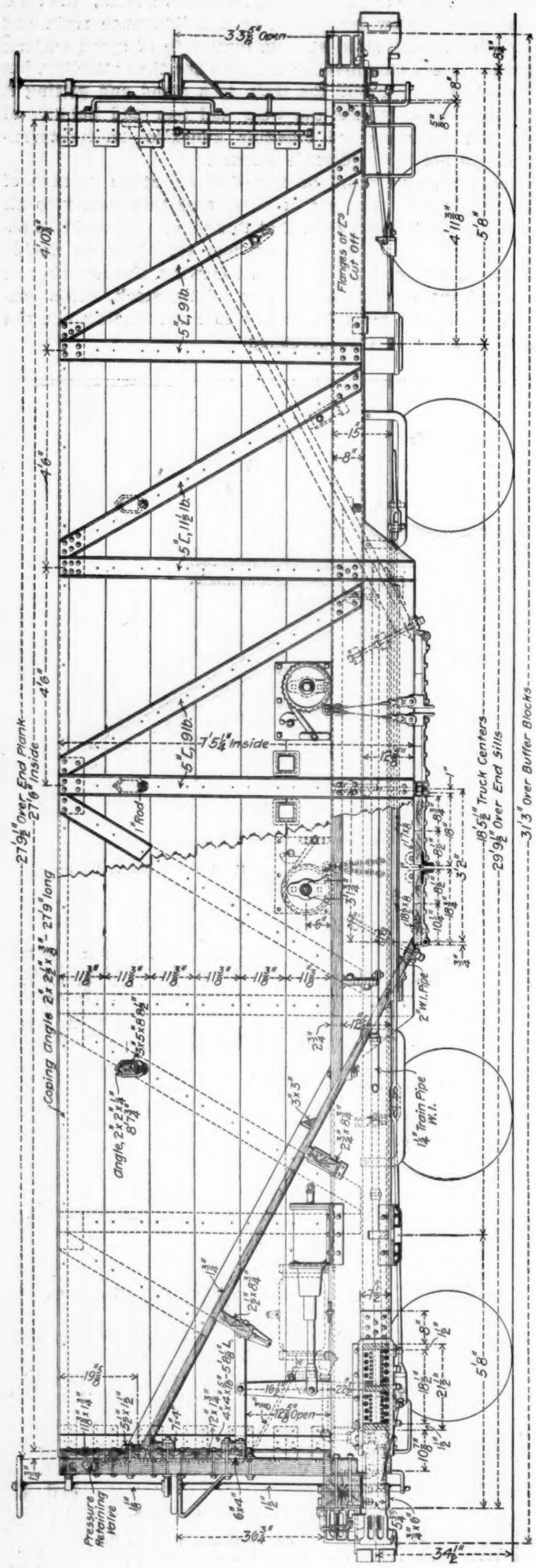
Elsewhere in this issue the enormous decapod tandem compound for this road is illustrated, and on page 38 of our February number is a description of another very powerful freight engine. These are specially heavy engines for special service. The accompanying engraving illustrates a much lighter freight engine of the consolidation type, which has just gone into ordinary road service, with promise of being very satisfactory.

On the division between Dodge City, Kan., and La Junta, Col., 202 miles, the usual rating of the freight engines is 1,800 tons. The average grade is 8 1-3 ft. per mile, found by dividing the total rise by the mileage. In one place there is a 34.3 ft. grade 35 miles long. On a test with a bad rail one of these engines hauled 68 loaded cars, or 2,426 tons, over this division in 24 hours 50 minutes, with 8 hours 27 minutes dead time, part of which was due to doubling the heaviest grade and the rest to interference from passenger trains. The actual running time was 16 hours 23 minutes, or an average speed of 12.4 miles per hour. The total amount of coal burned was 31 tons, and the coal per 100 ton miles was 12.7 lbs. Two days later another of these engines hauled 2,305 tons over the same division, with a good rail, without doubling. The tractive power, compound working, is 40,000 lbs. The following table presents a description of these engines.

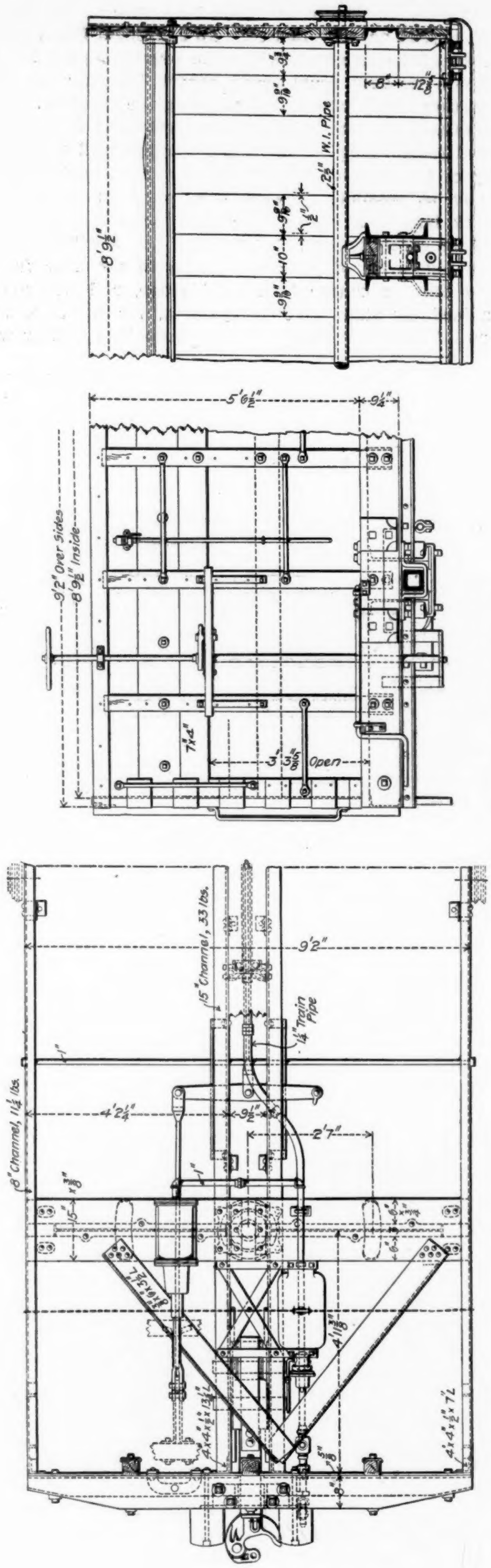
TANDEM COMPOUND CONSOLIDATION LOCOMOTIVE, ATCHISON, TOPEKA & SANTA FE.

Gauge	4 ft. 8½ ins.
Fuel	Bituminous coal
Weight in working order	201,000 lbs.
Weight on drivers	176,000 lbs.
Wheel base, driving	15 ft. 4 ins.
Wheel base, rigid	15 ft. 4 ins.
Wheel base, total	24 ft. 1 in.
Cylinders.	
Diameter of cylinders	16 ins. and 28 ins.
Stroke of piston	32 ins.
Horizontal thickness of piston	5½ ins.
Diameter of piston rod	4 ins.
Kind of piston packing	Plain rings
Tractive force, working compound	40,000 lbs.
Valves.	
Kind steam chest valve	Piston type
Greatest travel of valves	6 ins.
Steam lap of valves	⅞ in.
Exhaust clearance	L.P. ¼ in., H.P. line and line
Lead of valves in full gear	Line and line
Wheels, Etc.	
Diameter of driving wheels outside tire	57 ins.
Material of driving wheel centers	Cast steel
Driving box material	Main, cast steel; others, cast iron
Diameter and length of driving journals	9½ x 12main, 9 x 12 F. & B. & Int.
Diameter and length of main crank pin journals	6¾ x 6¾
Diameter and length of side rod crank pin journals	F. & B. 4½ x 4 Int. 5½ x 4½
Engine truck kind	2-wheel swing bolster
Engine truck journals	6½ x 10½
Diameter of engine truck wheels	31¼
Boiler.	
Style	Extended wagon top with wide firebox
Outside diameter of first ring	68 ins.
Working pressure	210 lbs.
Thickness of plate in barrel and outside firebox	11-16, ¾, 25-32, 9-16, & ½
Firebox, length	101⅛ ins.
Firebox, width	71¼ ins.
Firebox, depth	62⅛ ins. back, 71¾ ins. front
Firebox material	Lukens steel
Firebox plates, thickness	Crown, sides and back ⅜ in., tube ½ in.
Firebox water space	Front 4½ ins., back 4 ins., sides 4 ins.
Firebox crown staying	Radial, 1⅛ ins. diameter

(Table concluded on page 181.)



Half Section and Side Elevation



Partial Frame Plan, End View and Section.

40 TON COMPOSITE HOPPER CAR—NORFOLK & WESTERN RAILWAY.

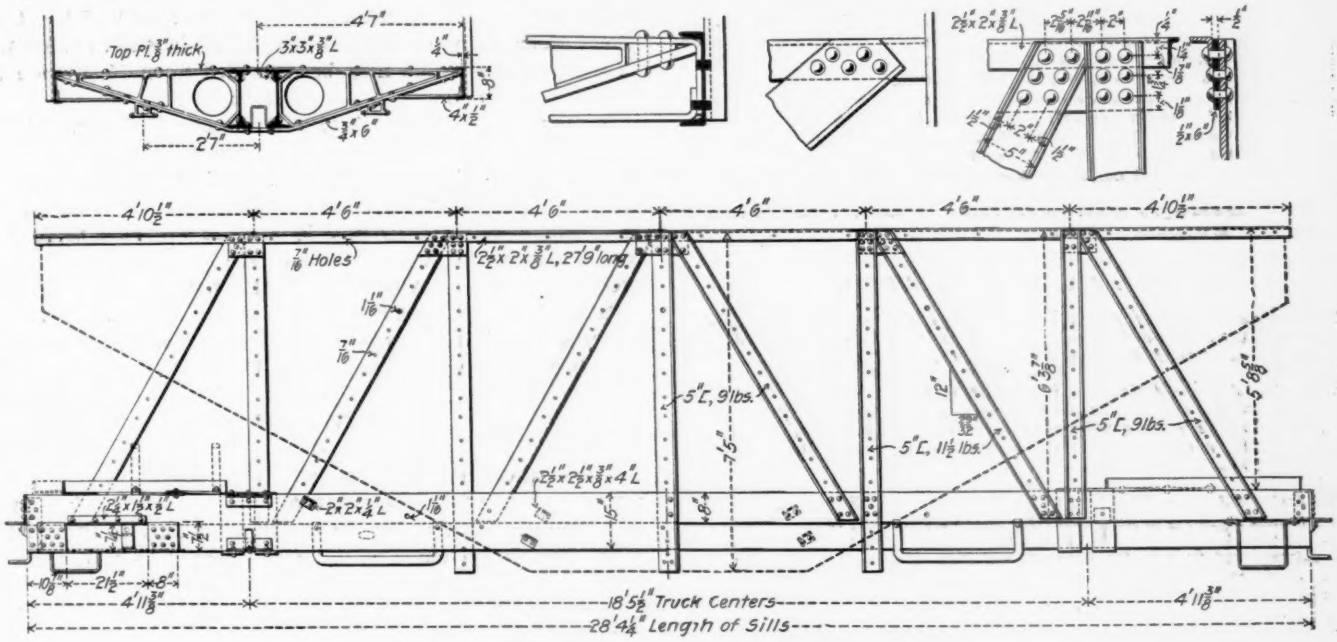
Firebox staybolts	Taylor iron, 1 in. diameter
Tubes, number of	355
Tubes, diameter	2 ins. O. D.
Tubes, length over tube sheet	15 ft. 0 ins.
Fire brick	Supported on arch tubes
Heating surface, tubes	2,787 sq. ft.
Heating surface, firebox	178 sq. ft.
Heating surface, total	2,965 sq. ft.
Grate surface	50 sq. ft.
Exhaust pipe	Single
Exhaust nozzles	5¼ ins., 5½ ins., 5¾ ins.
Smoke stack, inside diameter	15⅝ ins. to 18⅝ ins.
Smoke stack, top above rail	15 ft. 4 ins.
Boiler supplied by	2 Simplex No. 10 injectors

Tender.

Weight empty	46,400 lbs.
Wheels, number of	8
Wheels, diameter of	34¼ ins.
Journals, diameter and length	5 ins. x 9 ins.
Wheel base	17 ft. 6 ins.
Tender frame	A., T. & S. F. steel channel
Water capacity	6,000 gallons
Total wheel base of engine and tender	53 ft. 9½ ins.

the 40-ton flat-bottom gondolas of this road. One of the detail drawings shows the malleable-iron filling castings for the bolsters, with ⅝ by 15-in. top plates, and two ¾ by 6-in. bottom plates. As far as possible, this road has followed the policy of using the same details for a number of classes of cars, such as those already mentioned, also drop doors and air-brake details. These cars have the large flat-bottom center plate illustrated on page 75 of the issue of March, 1902.

This series of cars is unique in connection with steel construction. They are all successful, and all were developed on this road by Mr. C. A. Seley, formerly mechanical engineer, under the direction of Mr. W. H. Lewis, superintendent of motive power. They have demonstrated the advisability of utilizing the side frames for carrying a part of the load, and have also shown that composite construction is advisable where



40-Ton Composite Hopper Car—Norfolk & Western Railway

40-TON COMPOSITE HOPPER CARS.

Norfolk & Western Railway.

The Norfolk & Western has recently ordered 6,000 cars of various types, most of which are of the composite designs which we have illustrated. A noteworthy fact concerning the order for two of the classes is that after two years' service there is no change in the designs, not even a rivet. This confirms our opinion that these are remarkable designs, which are worthy of adaptation by other roads.

The new 40-ton hopper cars are intended for traffic for which the 50-ton car is too large. They are similar to the 500 cars built by this company in 1900 and illustrated in this journal in February, 1901, page 42, except that the new ones have one less pair of drop doors, the sides are 6 ins. lower and the center panel is omitted to cut down the capacity. The general dimensions are as follows:

Length over buffers	31 ft. 3 ins.
Length over end sills	29 ft. 9½ ins.
Length over body	27 ft. 9½ ins.
Length inside	27 ft. 6 ins.
Width over sides	9 ft. 2 ins.
Width inside	8 ft. 9½ ins.
Height over hopper	7 ft. 5 ins.
Estimated weight, new	34,500 lbs.

The center sills are 15 in. 33-lb. channels; the side sills, 8 in. 11¼-lb. channels, and the side posts and bracket, 5-in. channels, connected at their upper ends by gusset plates and also attaching to a heavy angle forming the top chord of the truss. This angle also serves as a coping for the wooden lining. The body bolsters and trucks are the same as those of lumber is as cheap as along this road. Descriptions of the earlier designs may be found in this journal as follows: Fifty-ton steel underframe hopper, June, 1899, page 187; 40-ton flat bottom, steel frame gondola, April, 1900, page 100; 50-ton steel frame hopper, February, 1901, page 42, and the 40-ton steel frame box car, May, 1902, page 140. Mr. Seley's article elsewhere in this issue presents a discussion of his views of the steel car question.

Mr. W. S. Morris has resigned as superintendent of motive power of the Chesapeake & Ohio, to succeed Mr. J. N. Barr as mechanical superintendent of the Erie. Mr. Morris is 45 years of age, and has spent 28 years in railroad service, beginning as an apprentice on the Housatonic Railroad. He was president of the Master Mechanics' Association last year. He has filled important positions on the Wabash, Missouri Pacific and other roads, and nine years ago was appointed to the position which he now leaves. He is sure to succeed in his new work, and he seems to be just the man to take up the work of Mr. Barr, which is enough to say of his ability. It will be a pleasure to everyone to know that preferment has come to Mr. Morris, even to those to whom his relations as head of the motive power department of the Chesapeake & Ohio have endeared him. It is safe to say that the most humble shop or repair track man will deeply regret his change. Mr. Morris is one to secure the "voluntary loyal support" of the rank and file, of which Mr. Deems writes in this issue. This journal congratulates Mr. Morris and the Erie Railroad.

(Established 1832.)

AMERICAN ENGINEER AND RAILROAD JOURNAL

PUBLISHED MONTHLY
BY
R. M. VAN ARSDALE,
J. S. BONSALL, Business Manager.
140 NASSAU STREET..........NEW YORK

G. M. BASFORD, Editor.
C. W. OBERT, Associate Editor.

JUNE, 1902.

Subscription.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union.*
Remit by Express Money Order, Draft or Post Office Order.
Subscriptions for this paper will be received and copies kept for sale by the
Post Office News Co., 217 Dearborn St., Chicago, Ill.
Damrell & Upham, 283 Washington St., Boston, Mass.
Philip Roeder, 307 North Fourth St., St. Louis, Mo.
R. S. Davis & Co., 346 Fifth Ave., Pittsburg, Pa.
Century News Co., 6 Third St. S., Minneapolis, Minn.
Sampson Low, Marston & Co., Limited, St. Dunstan's House, Fetter Lane, E. C., London, England.

EDITORIAL ANNOUNCEMENTS.

Advertisements.—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

To Subscribers.—*The* AMERICAN ENGINEER AND RAILROAD JOURNAL *is mailed regularly to every subscriber each month. Any subscriber who fails to receive his paper ought at once to notify the postmaster at the office of delivery, and in case the paper is not then obtained this office should be notified, so that the missing paper may be supplied.* **When a subscriber changes his address** *he ought to notify this office at once, so that the paper may be sent to the proper destination.*

A great deal is crowded into this issue, and it is hoped that the reader will give some thought to the broad ground which is covered. Motive-power men are engaged upon problems which have not heretofore been considered important, but are full of promise for the future.

In the variety of subjects discussed in this issue by well-known railroad officers even the casual reader must be impressed with the strong reflection of the opinion that the human element is to be exceedingly important in the progress of the immediate future. In all lines of industrial development it is becoming more and more difficult to find men who are properly prepared to meet the demands of constantly increasing responsibilities. Mr. Deems indicates that leaders must make a study of men. Mr. Delano suggests to educated young men that they should look upon railroad work as a profession. Messrs. Quayle and Lloyd indicate methods for getting men together for a complete study and understanding of their common problem. Important as the other subjects are, those relating to men, their encouragement and inspiration, appear to be the ones which require most careful and thoughtful attention.

THE STANDARD CAR.

Last October the American Railway Association adopted standard interior dimensions of 40-ton box cars and requested the Master Car Builders' Association to determine the corresponding exterior dimensions. A committee will report these dimensions at Saratoga this month.

The standard interior dimensions dispose of the traffic department difficulty by arranging the minimum rates in a way which will discourage the construction of other than cars of standard size, but the purpose of the American Railway Association was broader and deeper than this. The intention was to clear the way for actual standards in construction, so that standard timbers may be used in a standard design. It is important that the members of the Master Car Builders' Association should know this fact and that they should understand that the demand for standard construction has come from the managing officers. If this is understood the subject will undoubtedly be placed in the hands of a committee at the approaching convention, and as the use of steel, as well as wood, must be considered, its work will be difficult and interesting, as well as important.

In this issue will be found the opinions of influential railroad officers on this subject, and also an account of the exceedingly interesting action of the Union Pacific and other Harriman lines in the matter of standards. For business reasons standardizing seems to be the question of the time. There seems to be no danger of overdoing it, and the men who have made it possible may be depended upon to provide for future progress and to proceed carefully.

In connection with the length of the standard car, it is important that Mr. Sullivan's reference to the variation in length, in his article on page 163 of this issue, should be understood. This does not apply to new cars. Mr. Sullivan's statement should be carefully read by all who will have to do with this subject at Saratoga. It contains a clear and complete expression of what is expected of the Master Car Builders' Association. Not only must a standard car be adopted, but it must be safeguarded in a way which will permit of no trifling with the dimensions which have been adopted as standard.

"PER DIEM" HAS COME.

It now appears impossible for the present vicious and dishonest system of the payment for the use of "foreign" cars on a mileage basis to last or return after July 1, 1902. "Per diem" has been adopted by an official vote of 86 to 7, and this vote has just been confirmed by the signatures of the voters. It is to be tried for one year, but there can be no doubt of its permanency.

Next to the train rules, this is the most important work of the American Railway Association. Its effects cannot now be foreseen or appreciated. A careful study of the report of the committee on car service, through which this result was attained, compels admiration for its definite, clever expression and for the ability and foresight of its framers. It met with a determined but unavailing opposition, as we understand it, from those who desired to continue to pay dividends from the use of other people's property, for which proper compensation is not given under the present system.

The new system will place the car owner in control of his property and he will receive the per diem rate (20 cents, and $1.00 after 30 days) for every day his car is off his own lines. He may waive this on occasion if he chooses, and in the case of repairs his pay stops from the time special repair material is ordered until it is received by the road on which the car may be held for repairs. Thus the material will be hurried and also the repairs. In fact, "acceleration" all round seems to be the chief promise of the system. Foreign cars form a relatively small proportion of the cars in use by most roads, but the movement of these cannot be quickened without a corresponding effect upon home equipment. In Russia the average daily mileage of cars, under the per diem system, is about 80. In this country on some roads it is now as low as 18.

Such a reform is always difficult, and often the difficulties are proportional to the benefits. There are the best of reasons for congratulations upon the results and for high praise for those who have carried the movement forward. There is now no obstacle to the adoption of the standard car, and the Master Car Builders' Association will not fail to see this and act in the part of the work which is now at hand.

AMERICAN ENGINEER TESTS.

Locomotive Draft Appliances.

IX.

Report by Professor Goss.

SECTION IV.

A STUDY OF LIMITING CONDITIONS.

17. Purpose.—In choosing heights and diameters of stacks to be experimented upon, it was thought wise to have a complete understanding of the form and dimensions of a considerable number of stacks in use on modern engines. In the matter of height of stack, for example, it was thought not necessary to employ experimental stacks which should greatly exceed the limits which are fixed by conditions of service. To supply materials for such a study there was published in the American Engineer a request for information concerning front-end and stack arrangements, as applied to engines having a diameter of front-end greater than 64 ins. In a few cases, also, requests for information were transmitted by mail. All responses to these requests were in the end delivered to Professor William Forsyth, by whom they were studied, and whose report on the subject is presented in paragraphs 18 to 28, inclusive.

PROFESSOR FORSYTH'S REPORT.

18. The Sizes of the Locomotives Examined.—The size of the locomotive, so far as it affects the proportions of the stack, is best indicated by the diameter of the smoke-box and the size of the cylinders. Data covering these details, together with the proportion of stacks and height of nozzle for a number of representative modern locomotives, are given in Table IV. The diameters of smoke-boxes vary from 64 ins. to 84 ins., and the size of cylinders from 18 x 26 ins. to 23 x 30 ins., and for the high pressure cylinder of compound engines to 23 x 32 ins.

The locomotive at Purdue, upon which the experiments were made, has a smoke-box 55⅛ ins. in diameter, and the cylinders are 16 x 24 ins.

19. The Diameter and Shape of Modern Stacks.—While a few straight stacks are still used, the prevailing practice is to make the top diameter about 2 ins. larger than that at the choke. The minimum diameter of stack seems to bear no definite relation to the size of the cylinders or of the boiler. The stack having 14 ins. minimum diameter is used on the largest passenger engines having 75-in. smoke-boxes and 20 x 28-in. cylinders. Practice for passenger service allows a minimum diameter of 14 ins., and for freight 16 ins., the largest diameter at choke being 20 ins. This is an isolated case. The maximum diameter for all others is 17 ins. at the choke.

20. The Height of Choke from Top of Smoke Arch.—For this dimension the figures of the principal roads and locomotive works range from 3 ins. to 14 ins., while quite a large number of them, representing very good practice in locomotive design, use a height of about 7 ins. Two or three of the largest roads appear to use the same patterns for smokestacks for both passenger and freight service, for large engines having smoke-boxes 67 to 71 ins., and where the limit of height is reached the pattern is simply cut off at the top. With smoke-boxes above 80 ins. the choke is only 3 to 4½ ins. from the top of the smoke-box.

21. Height of Stack Above Smoke-Box.—The height of the center line of boiler above the top of the rail for large engines is now 9 ft. or more, and with a smoke-box 6 ft. in diameter its top is 12 ft. above the rail. For a maximum clearance line of 15 ft., which is as high as most roads can use, there remains only a distance of 3 ft. for height of stack above the smoke-box; for engines having smoke-boxes above 66 ins. in diameter the height of stack above the smoke arch is simply governed by this road limit, and it thus varies from 26½ to 39 ins. These stacks of 26½ to 36 ins. seem short, and the fact appears to be acknowledged, for all the roads use petticoat pipes of one form or another, which perhaps constitute in effect the equivalent of a stack inside of the smoke-box.

22. Inside Stacks.—On a number of roads there is found a gradual extension of the stack into the smoke-box, and while in some cases it has only reached the rudimentary stage of 4 ins., in others the stack extends down as far as 32½ ins. below the top of the smoke-box and within 5 ins. of the center line of the boiler. This form of stack is made 16 ins. in diameter at the lower end, straight within the smoke-box and

TABLE IV.

Proportion of Modern Locomotive Stacks and Nozzles.

Road or Locomotive Works.	Diameter of Smokebox. Inches.	Cylinders. Inches.	Top of Nozzle: Below Center of Boiler. Inches.	Top of Nozzle: Below Choke of Stack. Inches.	Top of Nozzle: Minimum and Maximum Diameter Inches.	Stack: Height above Smokebox. Inches.	Stack: Choke above Smokebox. Inches.	Stack: Top above Center of Boiler. Inches.
Bessemer and L. E.	84	24 x 32	3	48	16 -17	39	3	81
Pennsylvania Railroad	70	20½ x 26	15	53½	16 -18¾	35½	3½	70½
	73	20 x 28	20	86½	20 -21	35½	7	72
	73	22 x 28	17	60½	17 -18	40	7	71¾
	74	20 x 28	17	61	17 -18	34¾	7	77
New York Central	75	21 x 26	11	60½	14 -15½	27½	12	65
	70	20 x 28	9	47½	16½-16½	36¾	3½	72
	73	23 x 35 / 32	3½	52	14 -15½	26½	12	63
	70	20 x 28	13	62	16 -18½	39	14	74
Lake Shore (same stack)	69	20 x 28	4	45½	15 -16⅞	34½	7	69
	67	20½ x 28	3¼	43¾	15 -16⅞	34½	7	68
	71	21 x 30	5	47½	15 -16⅞	31¾	7	66¼
Chicago & Northwestern	71	20 x 28	5½	55	14 -16½	36	14	71½
	69	21 x 26	5½	54	14 -16½	36	14	70½
Brooks	71	21 x 26	6½	54½	16 -18½	31	12½	66½
	71	21 x 30	5	47½	15 -16⅞	32	7	67½
	85	23 x 30	7	54	15¼-18	31	4½	..
Schenectady	70¾	20 x 28	1¼	50½	14 -16½	34	14	69 3-10
	75⅛	21 x 26	10⅞	58	14 -16½	27½	10	65 1-16
	73½	21 x 26	5⅝	47¾	16 -17	31½	5	68⅛
	70¼	20 x 28	9⅛	48¼	16 -18½	33½	14	68⅝
Pittsburgh	64¼	18 x 26	3	47⅛	15 -16	45	12	77⅛
	68½	20 x 26	5⅛	45⅞	17 -17½	42	6½	76¼
	73	21 x 28	3⅛	45¾	15 -16	39	12	75½

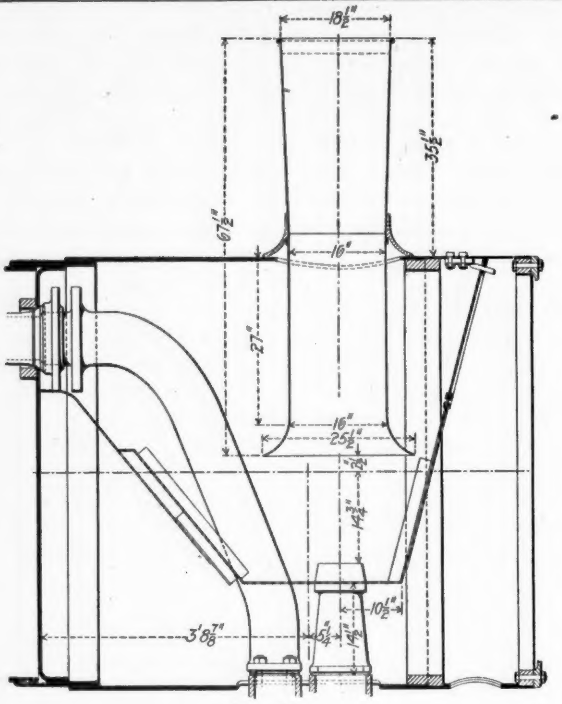


Fig. 19.

tapering outside to 18¾ ins. at the top for passenger engines, and for freight it is 20 ins. as a minimum and 21 ins. as a maximum.

The bottom of the stack is flared, trumpet shape, to a radius of 6 ins. This form of stack has been shown by Mr. J. Snowden Bell in his paper on "Locomotive Front-Ends," read before the Western Railway Club, September, 1899, page 25, and illustrated by Fig. 19 accompanying. Where these inside stacks are used an extremely low nozzle is also employed, so that the distance from top of the nozzle to the minimum diameter of the stack is 32 ins., and the total height of stack, from choke to top, is as much as 56 ins. for passenger and 62 ins. for freight locomotives. It will be seen, therefore, that some benefits must have been derived from the use of long stacks, since, in the case of engines which allow but short lengths outside, the stack has been extended inside until the effective height of stack has been increased to 62 ins. These long inside stacks having been adopted as standard by one of the largest roads, for all modern equipment, the tendency appears to be for other roads to follow this practice, and, as above stated, the drawings which have been reviewed indicate that quite a number of roads are gradually going through the same experimental stages as a preliminary to the process of extending their stacks down into the smoke-box. Where the inside stack is employed all the gases must be drawn down to a point near the center line of the boiler before they can enter the stack, and such an arrangement of baffle plates is required as will direct the gases down toward the center of the boiler, and thence upward through the stack, with danger of producing eddies which would injuriously affect the efficiency of the draft action.

It would seem that the inside stack opens up an entirely new field for discussion and experiment, and that while it constitutes a subject that cannot be gone into fully at this time, its successful operation indicates that it may be an efficient method of correcting the difficulties which are encountered when an attempt is made to use a short outside stack. Further experimental work in this connection will need to be directed towards the proper arrangement of the baffle plates and the proper height of the exhaust nozzle with respect to the choke of the stack, which now becomes located near the center line of the boiler instead of being above the top of the smoke-box. The self-cleaning quality of the front-end, possessed under some combinations of stacks and nozzles, is worthy of careful attention.

(To be Continued).

SUGGESTIONS CONCERNING LOCOMOTIVE ERECTING SHOPS.

By C. H. Quereau, Superintendent of Shops, New York Central & Hudson River Railroad, West Albany, N. Y.

The following remarks are presented not as a studied essay, but merely with a view to stimulating study and investigation. Assume, for consideration, a modern erecting shop, equipped with traveling cranes of ample power; under the conditions attendant upon such an equipment is it good practice to have the locomotives stripped and unwheeled on the pits where they are to be repaired, as is the usual practice? There are several reasons why it is better and more economical to have this work done on a special stripping pit.

If the stripping pit is properly located, there will be practically no more work put on the transfer table, or other means used in getting the locomotives into the erecting shop, by first delivering them to this stripping pit and then to the erecting shop tracks, than in placing them at once on the tracks where they are to receive their repairs. If the locomotives are stripped on the repair tracks, it is usual to have one or more gangs of men assigned to this special work who, when not doing this work, assist in the erecting shop; the pit foremen naturally, and almost inevitably, give considerable attention to the work of stripping, taking them away from the oversight of the erecting, while the delivery of the parts which are to go to the machine, boiler and blacksmith shops falls to the men employed on the erecting floor.

If the stripping of all locomotives, including the unwheeling, were done on one pit, there would naturally be a foreman in charge of the work, with a gang of laborers, receiving the minimum scale of wages, and this foreman and his men would soon become experts. In all probability the work would be done more cheaply and quickly under these circumstances than if done on each pit, as it seems more than probable that the work would be done more promptly by a foreman solely in charge of all this work than if under the charge of foremen who do this work at intervals, infrequently, and whose chief duty, concern and responsibility is to supervise repairs on a number of tracks. It seems reasonable to assume there would be less handling of blocking and similar material about the shop, and the floor could certainly be kept clean and tidy much more easily and at less expense if the blocking, waste and grease from journal boxes, dust and dirt from ash pans, fireboxes and front ends, etc., which cannot be entirely cleaned outside the shop, are confined to one pit, even if this special pit is not partitioned off from the rest of the shop.

It may be urged that, while the stripping is under the charge of the shop or gang foremen, there will be less liability of taking down parts which do not require removal either from their condition or from the nature of the repairs. This argument assumes that the shop or gang foreman, or both, should be the judges as to what work should be done on an engine; it would seem, however, that the better system would be to place this responsibility on the general foreman, who should determine by inspection what work is necessary and notify the erecting shop and stripping foremen. This should certainly be the system if piecework is employed. One of the most potent factors in the commercial development, reduced costs of manufacture and general betterment of the conditions of both employees and employers during the last hundred years has been the specialization of tools and workmen. This, of itself, appears to be a sufficient argument for the use of a special stripping pit.

It quite frequently happens that a locomotive requires very heavy repairs, such as a new boiler or firebox, new cylinders, or has a broken frame; under these circumstances it will probably be admitted that the stripping-pit system has quite an advantage over the other, because not only will the work of stripping and distributing of the parts be done more econom-

ically, but the erecting pits will not be idle while this work is beng done. It may be urged that this stripping-pit system would reduce the number of available erecting pits, and that this would be considered a serious objection to the plan; on the other hand, I am very strongly impressed that railroads, as a rule, spend considerably more money in building larger erecting shops than is necessary or advisable, and that appreciably larger dividends would be returned by the same money invested in locomotive repair shops, if the erecting shop capacity be considerably reduced and the money so saved devoted to machine, blacksmith and boiler shops and tools. Railroads get from one to two locomotives a month from each pit of their erecting shops, scarcely averaging one and a half—in all probability this output could be doubled.

Assume for the present that, with proper management, each pit of the erecting floor would turn out three locomotives a month instead of half that number, and that the money so saved is spent in betterments in the other shops. It is evident at once that the dividend-earning power of the money invested in the erecting shop, not considering the cranes and other equally valuable tools, is doubled; that the efficiency of the cranes is increased because of the shorter distances to be traveled; that the distance over which materials must be handled in the erecting shop is divided by two; that the money saved in the erecting shop building and spent in other shops will increase their capacity, and that there will be a saving in the ground devoted to erecting shop purposes. The greatest gain, however, will come from the fact that locomotives will average but ten instead of twenty days in the shop, and their earning capacities are increased to that extent, or that the number of locomotives necessary and the capital invested in them may be reduced proportionally.

Too often it is taken for granted that the capacity of a locomotive repair shop is limited by the number of pits in the erecting shop, and its size is thus proportioned to the number of locomotives to be taken care of, on the basis of an average number to be turned out by each pit per month, this average being usually assumed as about one and a half. A little consideration, however, will show that any number of men, from one to a dozen, can work to advantage on one pit, and even as many as twenty in emergencies, while one man can get the maximum product from a machine shop tool, two from a blacksmith's forge and anvil, and from one to three from each boiler shop tool. It therefore seems evident that the capacity of a locomotive repair shop is determined, within considerably wider limits than is usually assumed or indicated by current practice, by the capacity of the facilities outside the erecting shop, and that a reduction of the size of the usual erecting floor, with a corresponding increase in the facilities of the other shops, will increase the capacity of the plant as a whole, thereby increasing the earning power of the capital invested.

The usual capacity of a railroad erecting-shop pit is very frequently doubled by locomotive builders, and it is not unusual for them to more than double it. It is probably true that a repair shop erecting floor cannot equal the capacity of a manufacturing erecting floor having the same facilities and number of pits, because it is very difficult, if not impossible, to reduce the time lost in waiting for repaired parts to the extent which is possible when manufactured parts are used. I am, however, fully persuaded that a large part of the lost time in railroad erecting shops could be saved by introducing manufacturers' methods, and that two of the most potent factors in reaching this very desirable result are a smaller erecting shop floor and a pit devoted to stripping the locomotives.

The Santa Fe is reported to be using fuel oil for locomotives at the rate of 118,000 barrels per month and extending it to the lines east and north in California. The consumption on the Southern Pacific is stated to be 50,000 barrels per month. In a short time this fuel will be used exclusively on these roads in that State.

OIL FUEL FOR LOCOMOTIVES.

Hoosac Tunnel.

Boston & Maine Railroad.

The application of oil fuel to the Hoosac Tunnel helping locomotives by the Boston & Maine Railroad is a result of the necessity of keeping the tunnel clear of the smoke from the coal-burning engines.

The ventilating system in the tunnel is somewhat experimental in nature, and consists of a large fan, located in a central shaft rising from the middle of the tunnel upward 1,028 ft. to the top of the mountain, which fan may be operated to exhaust or force, but the success of this system depends greatly on the conditions of the weather and wind for its efficiency. As a rule, only one-half of the tunnel from one portal to the central shaft can be kept clear, even under the most favorable conditions, while the other half would remain contaminated. The heavy freight traffic passing through the tunnel, together with the necessity of double-heading between North Adams and the East Portal, owing to the grades of 26 ft. to the mile each way in the tunnel, has overtaxed the ventilating system and made it impossible to maintain the tunnel free from smoke. The tunnel A B is 4¾ miles long, and the prevailing grades from the Vermont line eastward may be seen from the accompanying profile of the road.

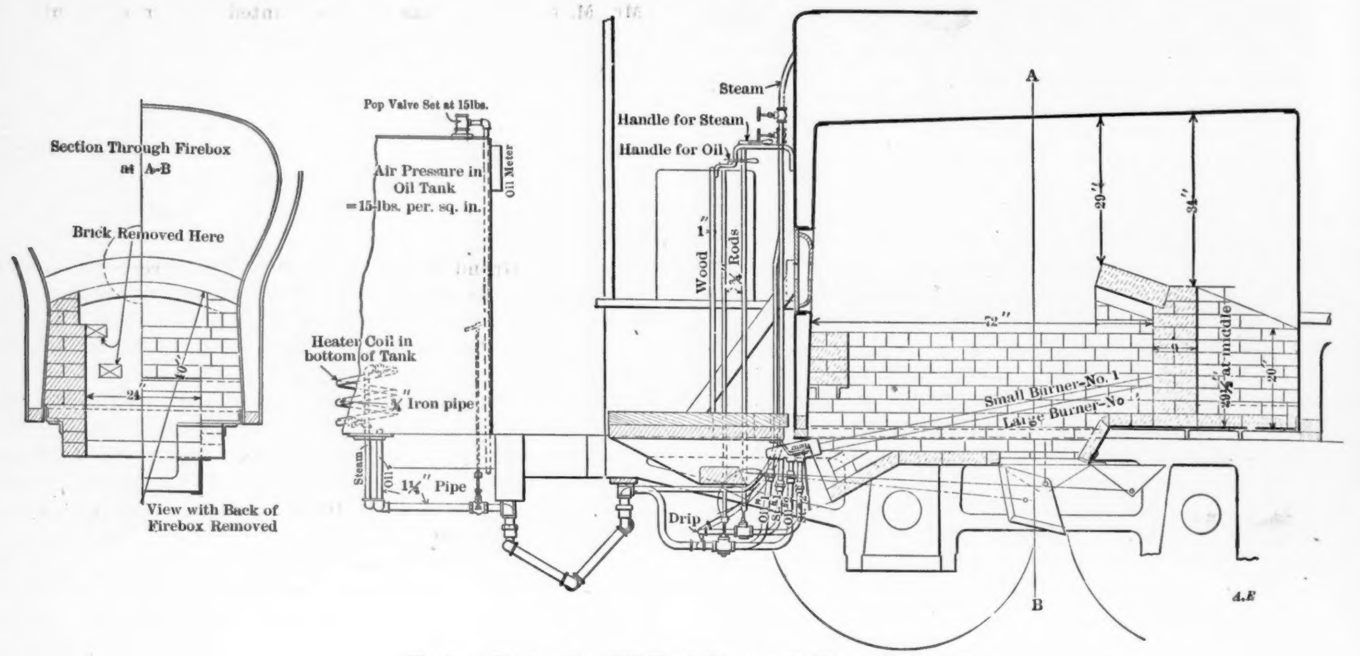
It was decided to fit up four of these helpers to burn petroleum oil (three of which are now at work and the fourth is being equipped in the shop), in which service it was necessary to provide:

1. Simplicity of arrangement, and duplication of all parts to which an accident might occur to stop the train.
2. Complete combustion of the fuel, leaving no smoke odor or gas.
3. Ability both to raise steam quickly and to hold steam under light fire for long periods.

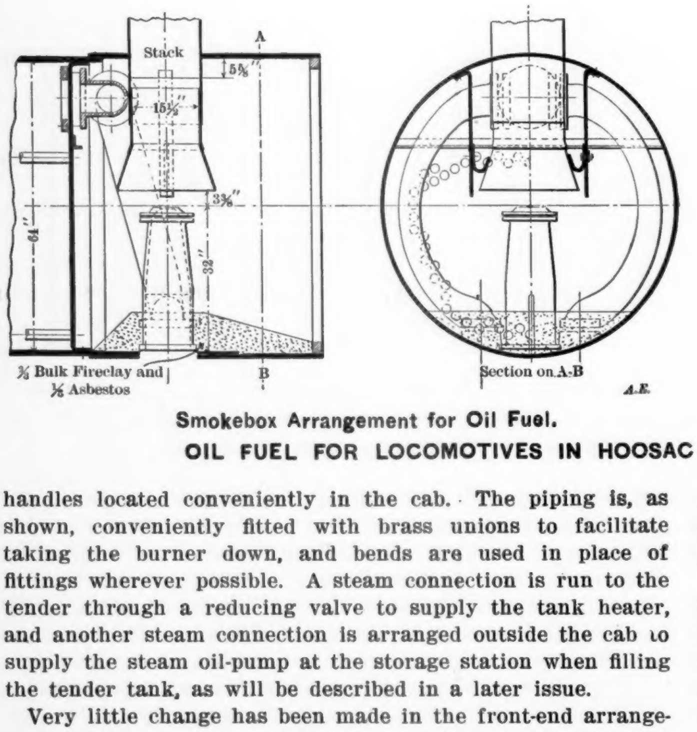
The most important change in the engines was that in the firebox arrangement. The drawing of the firebox shows the arrangement of the burner and the firebrick arch. As may be seen, the burner enters the firebox just beneath the rear water-leg and is inclined upward at an angle of 15 degrees, so as to direct the flame under the arch. The ashpan is replaced by a special pan which is bolted to the lower ring of the water-leg, and supports the firebrick lining and arch, as well as the dampers. The firebrick is laid up in alternate courses of headers and stretchers, although in front a single course of stretchers may be used, except in the center wall, which braces the arch to the tube-sheet. At the back end of the box a tie-wall is built in, resting on angle irons, to stay the side walls. The damper is arranged so that it may be entirely closed for holding steam with a light fire.

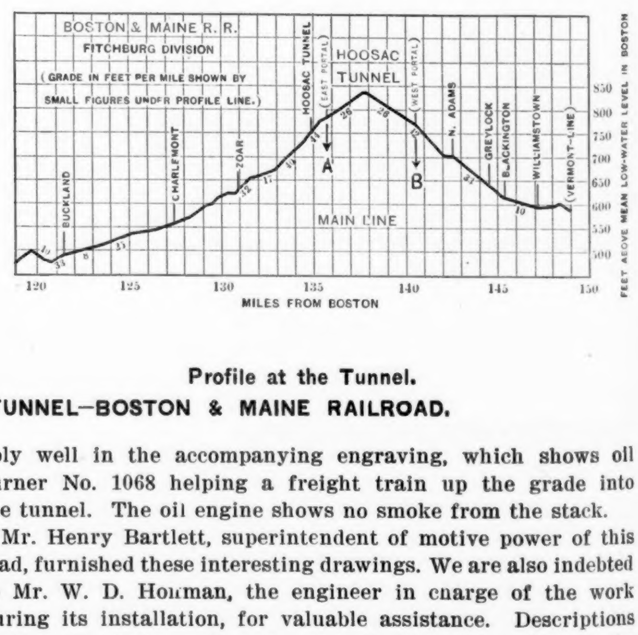
The burner is of ingenious construction, consisting of two burners in one, a narrow one on top and a wide one below. Both are flat, or slot, burners, with the steam arranged below that for the oil so as to blow through the stream of oil. A burner of this type, with properly proportioned steam slot and opening for the atomized spray, as the one shown, is capable of efficiently burning 150 gallons of oil per hour. A large air opening is provided near the burner to admit air for initial combustion, while the damper at the rear of the box furnishes what more is necessary. This burner has given good satisfaction, having never become stopped up. With the small burner it is possible to adjust the fire very low for the purpose of holding steam during long waits or delays, while with both burners a capacity far beyond any possible requirement is available.

The arrangement of the steam and oil piping for the burner is very simple. Oil is fed directly from the tender tank to the burners through throttle valves, and the steam is likewise controlled by throttle valves, all of which valves have their



Firebox Setting for Oil Fuel-Boston & Maine Railroad.





Smokebox Arrangement for Oil Fuel.

Profile at the Tunnel.

OIL FUEL FOR LOCOMOTIVES IN HOOSAC TUNNEL—BOSTON & MAINE RAILROAD.

handles located conveniently in the cab. The piping is, as shown, conveniently fitted with brass unions to facilitate taking the burner down, and bends are used in place of fittings wherever possible. A steam connection is run to the tender through a reducing valve to supply the tank heater, and another steam connection is arranged outside the cab to supply the steam oil-pump at the storage station when filling the tender tank, as will be described in a later issue.

Very little change has been made in the front-end arrangement in these engines except that all nettings and diaphragms were removed. The lower flaring edge of the petticoat pipe is 3⅜ inches above the exhaust nozzle and its upper end is 5⅝ inches below the bottom of the stack, as shown in the front-end sectional view.

It is stated that no repairs have been found necessary by the change in fuel, whereas since the change the work of three coal-burning helper engines has been done by two oil burners, and no hostler service is required at all. Steam is raised from cold water in the boiler in 40 minutes after starting the burner, and 200 pounds is indicated at the gauge in 50 minutes more. A pressure of 10 or 15 pounds will start the burners and in firing up this pressure is obtained from another engine. In one case one of the engines which had been without fire for 15 hours showed 150 pounds of steam at the gauge in 40 minutes after the burner was started. The efficiency of combustion in the oil burners is shown remarkably well in the accompanying engraving, which shows oil burner No. 1068 helping a freight train up the grade into the tunnel. The oil engine shows no smoke from the stack.

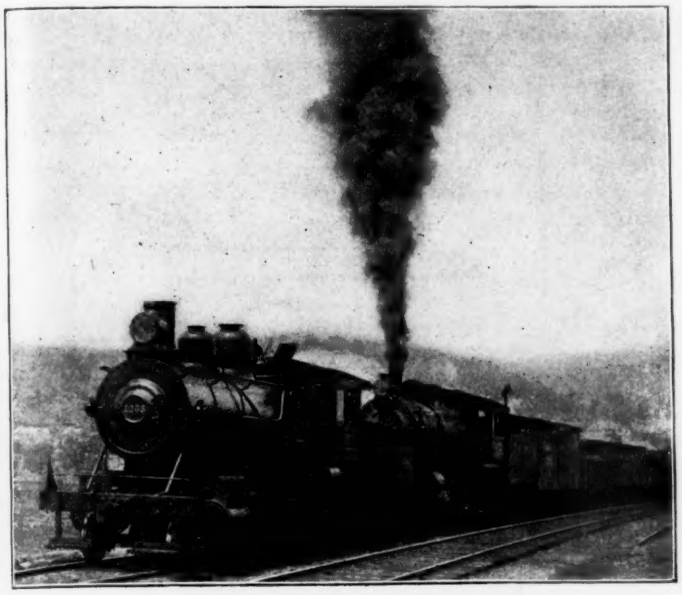
Mr. Henry Bartlett, superintendent of motive power of this road, furnished these interesting drawings. We are also indebted to Mr. W. D. Hoffman, the engineer in charge of the work during its installation, for valuable assistance. Descriptions of the oil storage, oil meter and further discussion of the firebox setting and the burner will be reserved for another article.

Tests will be made to compare oil and coal fuel in the same service and the results will be given in these columns.

The following is quoted from the official instructions issued to cover the operation of coal-burning engines used in connection with these helpers:

Helping engines equipped to burn oil fuel have been provided to help trains in both directions through the Hoosac Tunnel, and will work between Williamstown and East Portal, under the direction of the assistant superintendent of the western section.

The object is to reduce the amount of smoke and gas generated by coal-burning locomotives while in the Hoosac Tunnel. In all cases, except those of emergency, firemen must see that their fires are bright and clean and that they have full steam pressure before entering the tunnel. The use of green coal must be entirely avoided, except as above, while passing



Showing Contrast Between Fuel Oil and Coal. Both Engines Are Working Hard Up Grade Entering Tunnel. This Is a Fair Representation of the Results as to Smokelessness of Oil.

through the tunnel. With the present tonnage of freight trains, it is expected that the oil-burning helpers will be able to help the road engine sufficiently to enable it, when entering the tunnel with fire in proper condition and steam of proper pressure, to take the balance of the tonnage through without using fresh coal.

Suitable arrangements will be made at North Adams to hold eastbound trains on the sidings east of the station in the event of any delay in entering the tunnel, in order that firemen may have an opportunity to get their fires bright and in proper condition before entering the tunnel.

Fatalities among conductors, brakemen, switchmen, flagmen and watchmen in coupling accidents, in the year ending June 30, 1901, have, according to the Interstate Commerce Commission, decreased about 35 per cent. from the figures of the previous year. The number injured decreased about 52 per cent. These figures represent 70 per cent. of the mileage of the country, and the reduction of accidents seems to be due to the progress in safety appliances.

The adoption of a standard cipher code for all departments of railroad work was suggested at the recent meeting of the American Railway Association, with a view of reducing the number of words in telegraphic correspondence. It was placed in the hands of a special committee for report at the next meeting.

F. A. Krupp, of Essen, has been awarded the Bessemer Medal of the Iron and Steel Institute. The late Mr. A. Krupp began business as a workman at the crucible. He developed his enterprise himself, serving as steel worker, bookkeeper, manager, salesman and all, and became the owner of the largest steel and iron establishment in the world. His scn ably extended the business, and now employs twice as many workmen as his father did. He is at present the sole proprietor of works employing 47,000 men.

The Q & C Company, manufacturers of railway specialties, machinery and pneumatic tools, will operate in their own name, with C. F. Quincy as president, commencing June 1, with offices in the Western Union Building, Chicago, and 114 Liberty street, New York. The general sales department will be located at the shops at Chicago Heights, Ill.

PERSONALS.

Mr. M. S. Monroe has been appointed master mechanic of the Macon, Dublin & Savannah Railroad, with headquarters at Macon, Ga.

Mr. H. A. Furgusson has been promoted to the position of assistant superintendent of motive power of the Chicago Great Western from that of general foreman at Oelwein, Ia.

Mr. W. D. Robb has been made superintendent of motive power of the Grand Trunk, with office at Montreal. His title has been acting superintendent of motive power.

Mr. F. W. Cox has been appointed master mechanic of the Chicago, Milwaukee & St. Paul at West Milwaukee, Wis., having been transferred from a similar position at Sioux City, Ia.

Mr. J. W. Luttrell has resigned as master mechanic of the Illinois Central at Burnside to succeed Mr. J. O. Pattee as superintendent of motive power of the Missouri Pacific, with headquarters at St. Louis, Mo.

Mr. J. H. Vought has been promoted from the position of master mechanic to that of assistant superintendent of motive power of the Lehigh Valley, with headquarters at Bethlehem, Pa.

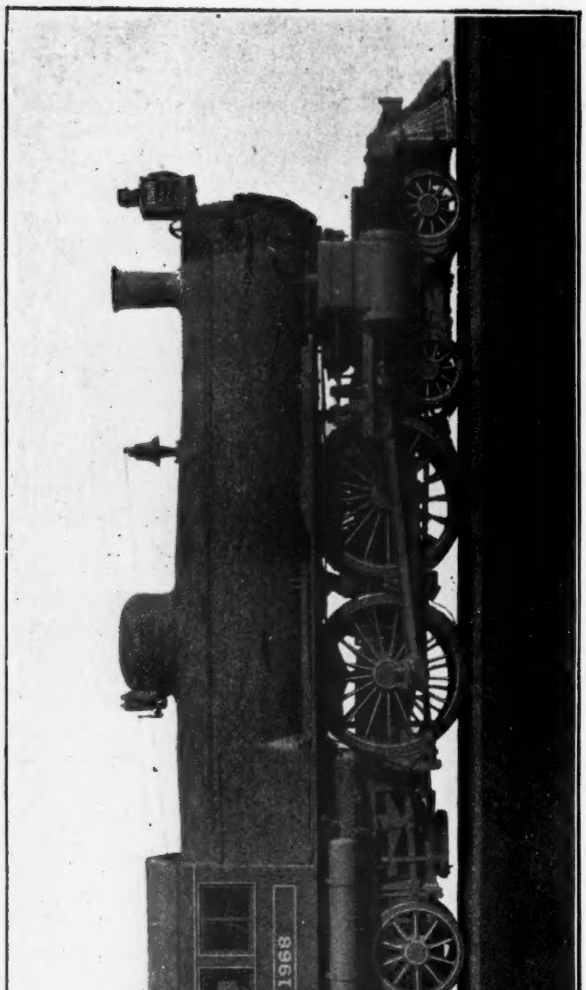
Mr. J. N. Barr has resigned as mechanical superintendent of the Erie to become general superintendent of the Chicago, Milwaukee & St. Paul Railway, and thus another leading motive power officer is called to greater operating responsibilities.

Mr. J. A. Pilcher has been appointed mechanical engineer of the Norfolk & Western, to succeed Mr. C. A. Seley. Mr. Pilcher was formerly connected with the road when Mr. George R. Henderson held this position, and has for a number of years been one of the leading designing draughtsmen at the Baldwin Locomotive Works.

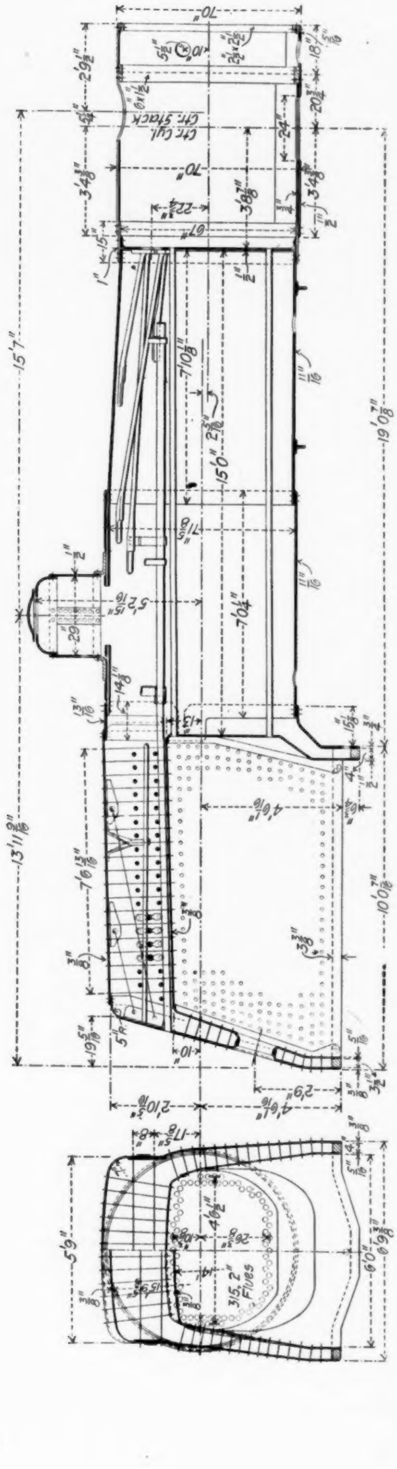
Mr. W. E. Symons, formerly of the Plant System, has been appointed mechanical superintendent of the Gulf, Colorado & Santa Fe, with headquarters at Cleburne, Tex. He expected to take a rest and study locomotive progress for several months in Europe, but the demand for his services would not permit. His new position places him in charge of the Santa Fe lines in Texas, one of the most important districts of the road. He thus returns to the Southwest, where much of his success and reputation have been earned.

Mr. Clement F. Street, member A. S. M. E., has resigned as manager of the railroad department of the Dayton Malleable Iron Company to join the staff of the Wellman-Seaver-Morgan Engineering Company, of Cleveland. Mr. Street has had a wide experience with engineering firms and railroads, and is best known in his work as editor of the "Railway Review," of Chicago. He was a member of the World's Transportation Commission, and in that capacity spent two years in studying transportation methods in all parts of the world. Being thoroughly informed in the engineering requirement of railroads he will be a valuable addition to the staff of the company which he now joins.

Mr. A. N. Spencer, second vice-president of the J. A. Fay & Egan Company, of 409 to 429 West Front street, Cincinnati, O., will represent that company at the Saratoga convention and have charge of their exhibit. This firm has made a specialty of the development of heavy woodworking tools for car construction, and their experience enables them to give valuable assistance in connection with the modernizing of woodworking departments.

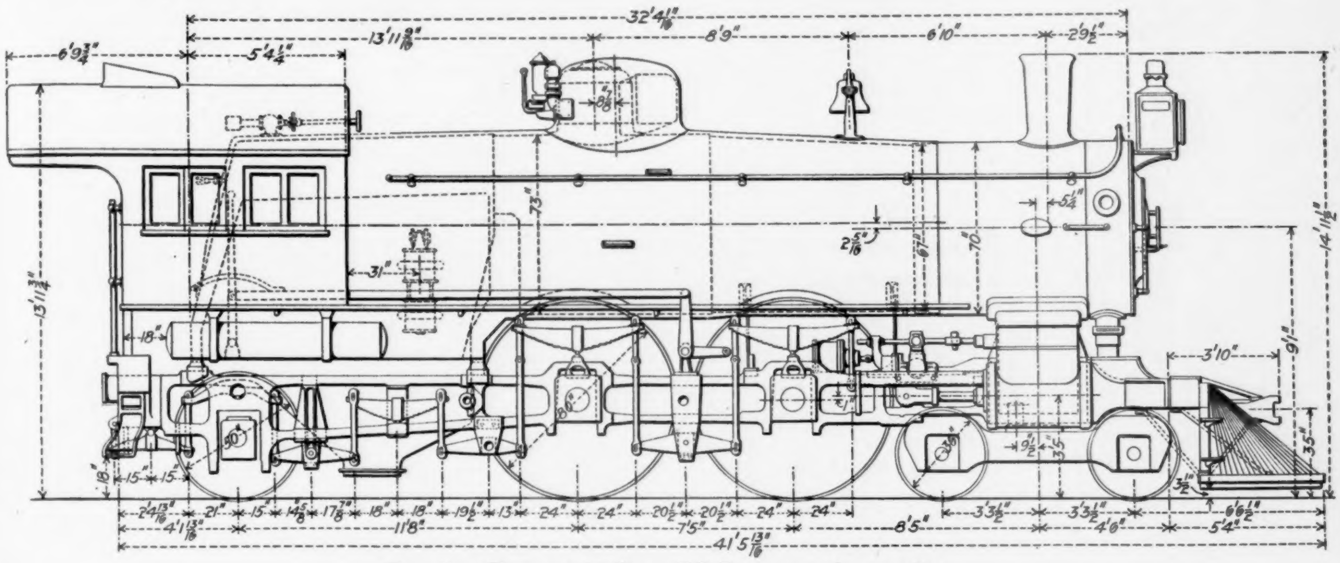


Atlantic Type Fast Passenger Locomotive—Pennsylvania Railroad.
Class E 2

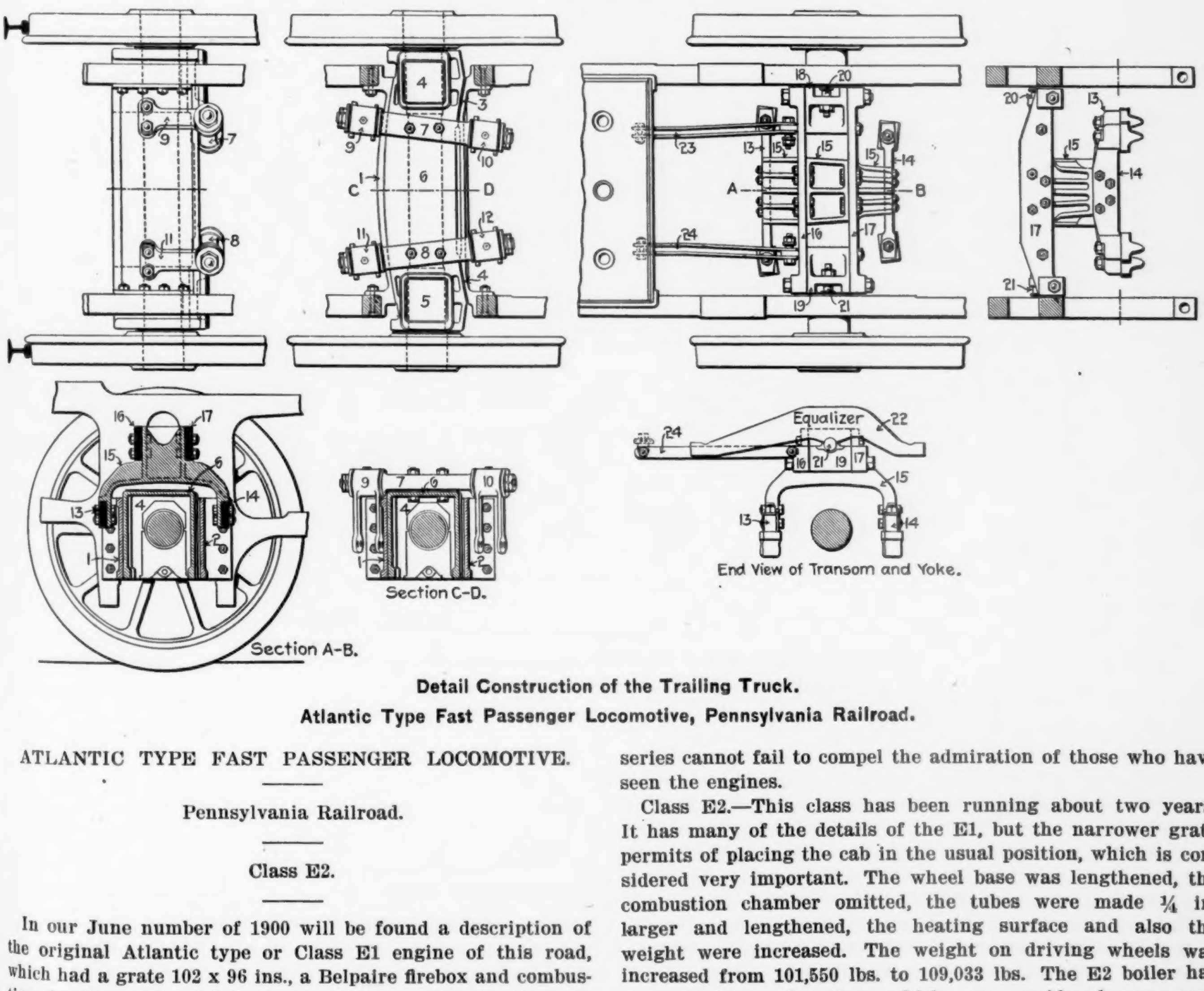


Boiler of Class E 3a Fast Passenger Locomotive.

ATLANTIC TYPE FAST PASSENGER LOCOMOTIVE—PENNSYLVANIA RAILROAD



Elevation Diagram of Class E 2 Passenger Locomotive.



Detail Construction of the Trailing Truck.
Atlantic Type Fast Passenger Locomotive, Pennsylvania Railroad.

ATLANTIC TYPE FAST PASSENGER LOCOMOTIVE.

Pennsylvania Railroad.

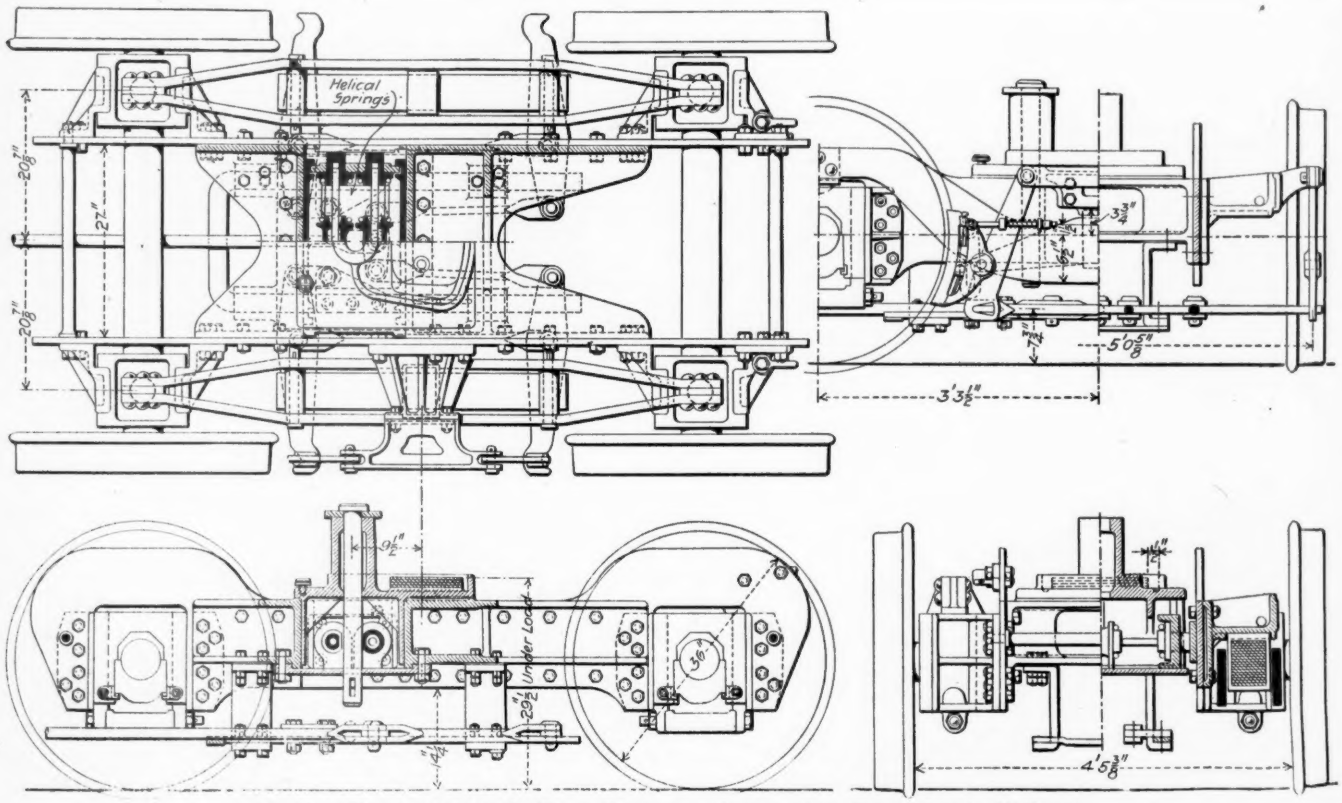
Class E2.

In our June number of 1900 will be found a description of the original Atlantic type or Class E1 engine of this road, which had a grate 102 x 96 ins., a Belpaire firebox and combustion chamber. The wide firebox made it necessary to place the cab over the barrel of the boiler, and thus separated the enginemen. This is a remarkable engine, and is one of the best examples of design in detail which has ever been produced. It is also one of the most important on this road, as a predecessor of the later passenger engines with the same wheel arrangement but different boilers and sizes of cylinders. This series cannot fail to compel the admiration of those who have seen the engines.

Class E2.—This class has been running about two years. It has many of the details of the E1, but the narrower grate permits of placing the cab in the usual position, which is considered very important. The wheel base was lengthened, the combustion chamber omitted, the tubes were made ¼ in. larger and lengthened, the heating surface and also the weight were increased. The weight on driving wheels was increased from 101,550 lbs. to 109,033 lbs. The E2 boiler has a round top, a departure which was considered an experiment. In the E3 design, the next step in advance, the cylinders were increased to 22 x 26 ins., and the boiler also had a round top. It is understood that the larger cylinders were adopted for special road conditions on the Pittsburg division, where these engines are used. The next step, the E3a. will return to the Belpaire firebox top, but retain the 72-in. grate

ATLANTIC TYPE LOCOMOTIVES, PENNSYLVANIA RAILROAD.

Character of service	Passenger			
Type of wheel arrangement	Atlantic			
Classification	E1	E2	E3	E3a
Diameter of drivers, in inches	80	80	80	80
Size of driving axle journals, in inches	9¼ x 8½ x 13	9½ x 13	9½ x 13	9½ x 13
Driving wheel base	7 ft. 5 ins.	7 ft. 5 ins.	7 ft. 5 ins.	7 ft. 5 ins.
Total wheel base of engine	26 ft. 6½ ins.	30 ft. 9½ ins.	30 ft. 9½ ins.	30 ft. 9½ ins.
Total wheel base of engine and tender	50 ft. 5 ins.	60 ft. 1 13-16 ins.	60 ft. 1 13-16 ins.	60 ft. 1 13-16 ins.
Number of wheels in engine truck	4	4	4	4
Diameter of wheels in engine truck	36 ins.	36 ins.	36 ins.	36 ins.
Size of engine truck axle journals	5½ x 10	5½ x 10	5½ x 10	5½ x 10
Spread of cylinders	85½ ins.	85½ ins.	85½ ins.	85½ ins.
Size of cylinders, in inches	20½ x 26	20½ x 26	22 x 26	22 x 26
Steam ports, in inches	1½ x 20	1½ x 20	1½ x 20	1½ x 20
Exhaust ports, in inches	3 x 20	3 x 20	3 x 20	3 x 20
Travel of valve, in inches	7	7	7	7
Lap of valve, in inches	1½	1½	1½	1½
Type of boiler	Belpaire	Round top	Round top	Belpaire
Minimum internal diameter of boiler	65⅞	65	65	65
Number of tubes	353	315	315	315
Outside diameter of tubes	1¾	2	2	2
Length of tubes between sheets	156 ins.	180 ins.	180 ins.	180 ins.
Fire area through tubes, square feet	4.33	5.26	5.26	5.26
Size of firebox, inside	102 x 96	72 x 111	72 x 111	72 x 111
Grate area, square feet	68	55.5	55.5	55.5
External heating surface of tubes	2102.4	2474.0	2474.0	2474.0
Heating surface of firebox, square feet	218	166	166	166
Heating surface, total, square feet	2,320.4	2,640	2,640	2,640
Steam pressure	185	205	205	205
Number of wheels under tender	6	8	8	8
Diameter of tender wheels	42	36	36	36
Tender axle journals, size	5 x 9	5½ x 10	5½ x 10	5½ x 10
Weight of engine empty, in pounds	154,700	157,033	158,000	158,000
Weight in working order, front truck	38,125	36,650	37,000	37,000
Weight in working order, first pair drivers	50,250	53,800	54,000	54,000
Weight in working order, second pair drivers	51,300	55,233	55,500	55,500
Weight on trailing wheels	33,775	30,917	31,000	31,000
Weight of engine in working order	173,450	176,600	177,500	177,500
Weight of tender loaded	90,000			
Ratio heating surface to grate area	34.2	47.56	47.56	47.56
Ratio tube heating surface to firebox heating surface	9.6	14.9	14.9	14.9
Tractive power per pound M. E. P.	136.6	136.6	136.6	136.6
Tractive power per pound M. E. P. at 4-5 boiler pressure	20,220	22,400	22,400	22,400
Trailing wheels, diameter	56 ins.	50 ins.	50 ins.	50 ins.
Trailing axle journal, size of	7 x 11¾	7 x 11¾	7 x 11¾	7 x 11¾



Leading Truck of Atlantic Type Passenger Locomotive, Pennsylvania Railroad.

of the E2. The E3 designs are heavier and more powerful than the earlier ones, with 109,500 lbs. on the driving wheels, which is the greatest weight in our record of Atlantic type engines. For convenience in comparison, the characteristics of the four designs referred to have been tabulated in this description.

While the E2 engine is not a standard, it marks an important step in that direction and is worthy of record, because of its remarkable success in handling fast and heavy passenger trains. This class has done specially noteworthy service on the line between Camden and Atlantic City, where the conditions are particularly severe.

As stated, the E2 boiler is of the radial stayed type. This road has long favored the Belpaire firebox, because of its direct staying with straight line stresses, and experience in this case leads to a return to it because it is believed to better provide for the expansion stresses. The running gear is generally the same as that of the E1, except as to the leading and trailer trucks and the spring rigging, which is modified at the back end because of the new trailer trucks.

In the boilers of recent engines on this road, special care is taken to secure free passage of water at the throat into the water space around the firebox. The water space at the throat widens rapidly above the vertical portions of the sheets, and this should greatly improve the circulation. Methods of supporting the fireboxes to the frames have also been most carefully studied in order to provide for wear and to take care of the stresses without subjecting the firebox plates to bending. The boiler support used in these engines is known as the Tate boiler clamp.

The main rod of this engine is similar to that of Class E1, and represents the most recent development in this direction. The end of the rod is forked, and is provided with a gib bolt, which prevents the forks from spreading. This bolt slopes on the forward side to fit the slope of the taper key, and it is made of D section. A U-shaped block or liner fits in the forks and bears against the liner of the brass on one side and against the key on the other side. In this way about 4 ins. of metal resists the stresses which may be produced by water in the cylinder. If shearing does occur, the rod end can still be taken down. This construction was adopted because it is lighter and stronger than a strap.

Leading Truck.—This truck has side plates, terminating at their ends in palms, to which the journal box guides are bolted. The transoms are of cast iron, with long flanges bolted to the side frames. Between the transoms is a saddle, moving laterally, the saddle containing a spring box to secure the centering movement. Upon the top of the saddle is the centerpin, which is placed to bring the center of rotation 9½ ins. back of the center of support, a plan which was developed in connection with the E1 engine, but in this case side motion is also provided. This centering of the truck gives equal weight on all the wheels, but gives to the leading wheels a larger leverage in guiding. A pocket contains the lubricant, and the wear is received upon liners which are adjustable. This truck is equipped with air-brakes.

Radial Trailing Truck.—When the wheel-base of the E1 engine was increased, it became necessary to design a new radial trailer truck, and this was worked out to secure the centering action by gravity, instead of by a spring. This construction gives about 3½ ins. side motion each way from the center. Between the engine frames are placed two guide-plates, 1 and 2, having curved faces of suitable radius. The rear guide is curved throughout its whole length, but the forward guide has its curved faces, 3 and 4, located near the ends only. Between these are placed the truck journal boxes, 4 and 5, which are integral with the connecting piece, 6, curved in plan and in the form of an inverted trough. On the top of the connecting piece between the boxes are rigidly bolted the axles, 7 and 8, which are journaled at their ends for the purpose of carrying the inverted T-shaped hangers, 9-10 and 11-12. These axles are placed radially to the curves of the guiding faces, and each is fitted at its lower end with two pins connecting the legs of the hangers. Upon these pins rest the transoms, 13 and 14, which at their ends are fitted with special bearing blocks so shaped that a tooth-formed projection fits between the two pins at the lower end of the hangers, thereby permitting the axle wheels and boxes, with the parts fastened to them, to move laterally without danger of the transoms slipping out of the hangers. Resting upon these transoms and fastened to them is the yoke, 15. Resting upon the latter and fastened to it are the transoms, 16 and 17. These transoms are of a length nearly equal to the distance between the engine frames, but are not attached in any way to the latter. Spacing blocks, 18 and 19, are bolted to these transoms at the ends. These blocks carry at their outer ends bearing pins, 20 and 21, upon which the equalizers rest. One only of these, 22, is shown. To prevent any tendency of the long transoms to rotate, they are tied by two sets of links, 23 and 24, to the foot-plate, permitting them, however, to rise and fall to whatever extent is demanded by the equalizing system.

DECAPOD TANDEM COMPOUND FREIGHT LOCOMOTIVE.

Atchison, Topeka & Santa Fe Railway.

The Most Powerful Locomotive in the World.

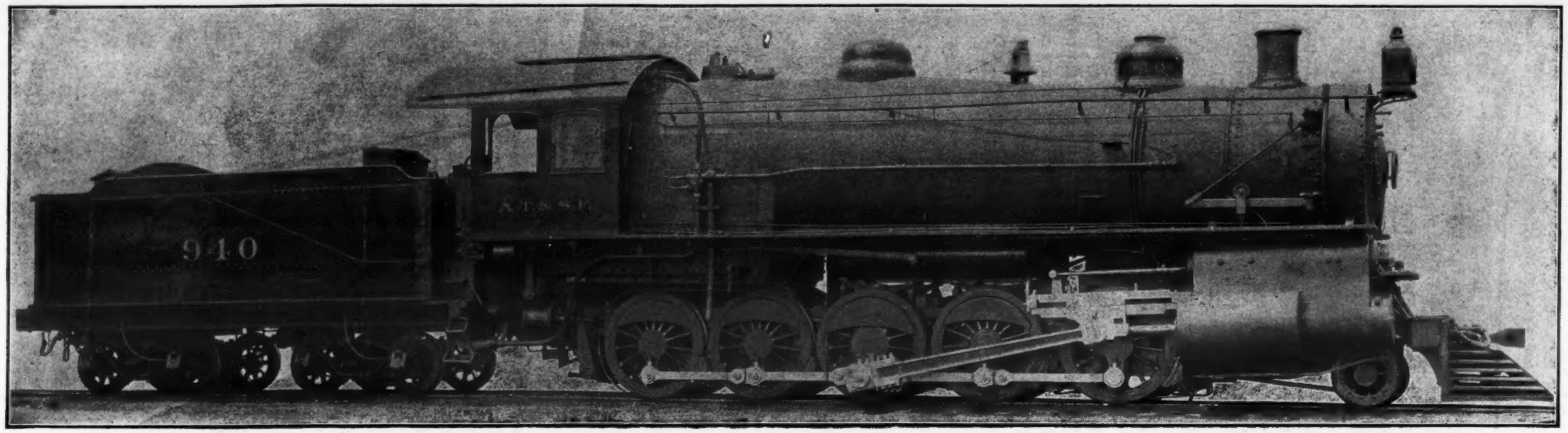
A locomotive with 62,500 lbs. tractive power, 5,390 square feet of heating surface, and a total weight of 267,800 lbs., has just been delivered by the Baldwin Locomotive Works to the Atchison, Topeka & Santa Fe Railway. It is the largest and most powerful locomotive in the world, and has set a mark so high that it seems improbable that it will be surpassed for some time to come. A glance at the photograph, the height of the stack and the location of the whistle, conveys an impression of its enormous size.

It has the largest cylinders ever applied to a four-cylinder engine, and the boiler is the largest ever constructed. An idea of the size of the details is had from the equalizer of the pony trucks, which is 13 ins. deep at the center. The main crank-pin is 8¼ x 8½ ins. The crossheads are of the Laird pattern, with 4 x 9-in. (top) and 6¼ x 5-in. (bottom) guides. The pistons are of cast iron, with babbitt rings. One of the most interesting features is the cylinder and valve construction. The high-pressure cylinder is secured to the front of the low-pressure, and the connection between the steam chests is made in the form of a packed gland or slip joint, which is easily separated and requires no close machine fitting. For convenience in handling the high-pressure cylinder, a small crane is permanently mounted on the side of the smoke-box, the cylinder being lifted by a ring located over its center of gravity. Only one joint needs to be ground in, and access may be had to the low-pressure pistons without taking the guides down. A special form of piston-rod packing made by the United States Metallic Packing Company is used between the two cylinders. It takes care of vertical and lateral movements of the rod. Instead of crossing the ports of the high-pressure cylinder, the valve for that cylinder is double-ported, as shown in the engraving.

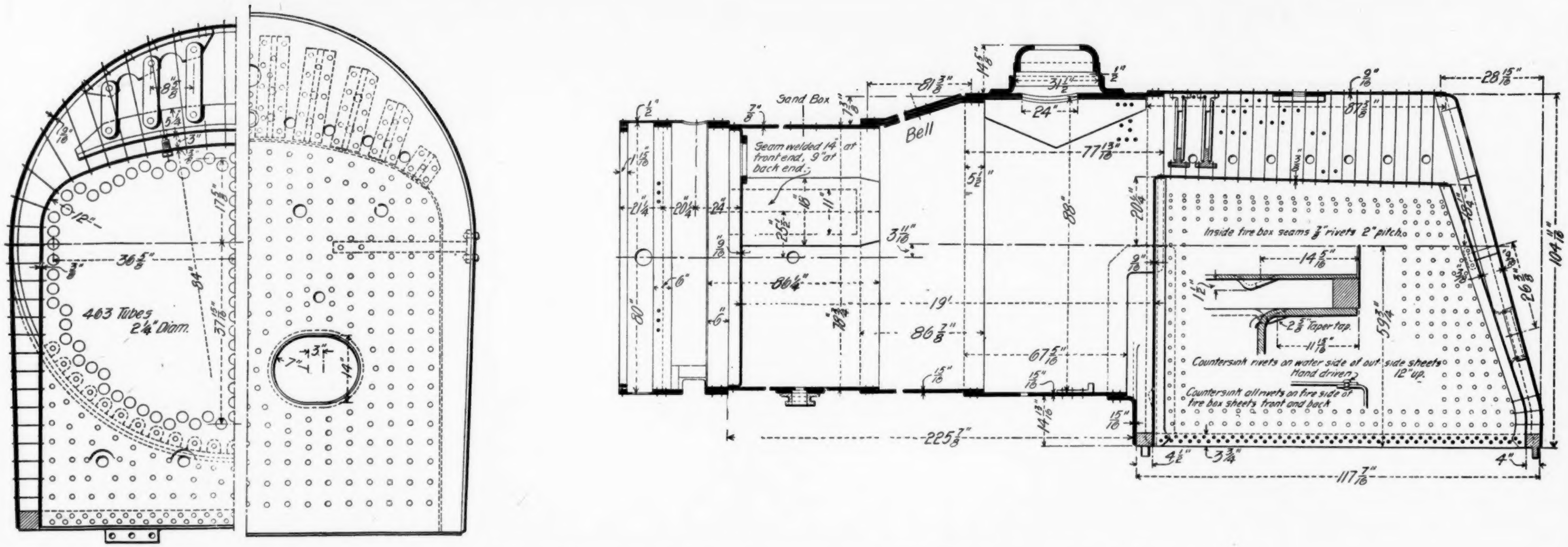
In simple working this engine is equivalent to one with 25.44-in. simple cylinders, and as a compound, to one with 24¼-in. cylinders. The cylinder power is calculated to be sufficient to slip the wheels with a boiler pressure of 200 lbs. All of the tires except the third pair are flanged. The first and fifth pairs of driving tires are set at a distance of 53⅛ ins. apart, the others being 53⅜ ins. The Le Chatelier water brake, as well as the Westinghouse, is applied to this engine, as its service is to be on the heaviest mountain grades on this road. We regret that space is not available in this issue for comment upon other interesting features of this remarkable design. Its place among heavy locomotives may be seen in the table published in the insert with this issue. The principal dimensions of the engine are as follows:

DECAPOD TANDEM COMPOUND FREIGHT LOCOMOTIVE.
Atchison, Topeka & Santa Fe Railway.

Gauge	4 ft. 8½ ins.
Fuel	Soft coal
Weight in working order	267,800 lbs.
Weight on driving wheels	237,800 lbs.
Weight on leading truck	30,000 lbs.
Wheel base, driving	20 ft. 4 ins.
Wheel base, rigid	20 ft. 4 ins.
Wheel base, total of engine	29 ft. 10 ins.
Wheel base, total, engine and tender	59 ft. 6 ins.
Cylinders.	
Type	Tandem compound
Diameters of cylinders	19 and 32 ins.
Stroke of pistons	32 ins:
Valves.	
Type of	Piston
Diameter	13 ins.
Travel of valves	6 ins.
Outside lap	H.P. ⅞ in., L.P. ¾ in.
Inside lap (negative)	H.P ¼ in., L.P. ⅜ in.
Lead of valves	L.P. ⅛ in.
Throw of eccentrics	6 ins.
Steam ports, length	29¾ ins.
Steam ports, width	H.P. 1⅝ ins., L.P. 1¾ ins.
Bridges	H.P. 2¼ ins., L.P. 2⅝ ins.
Exhaust ports, length	29¾ ins.
Exhaust port, width	[illegible] ins.

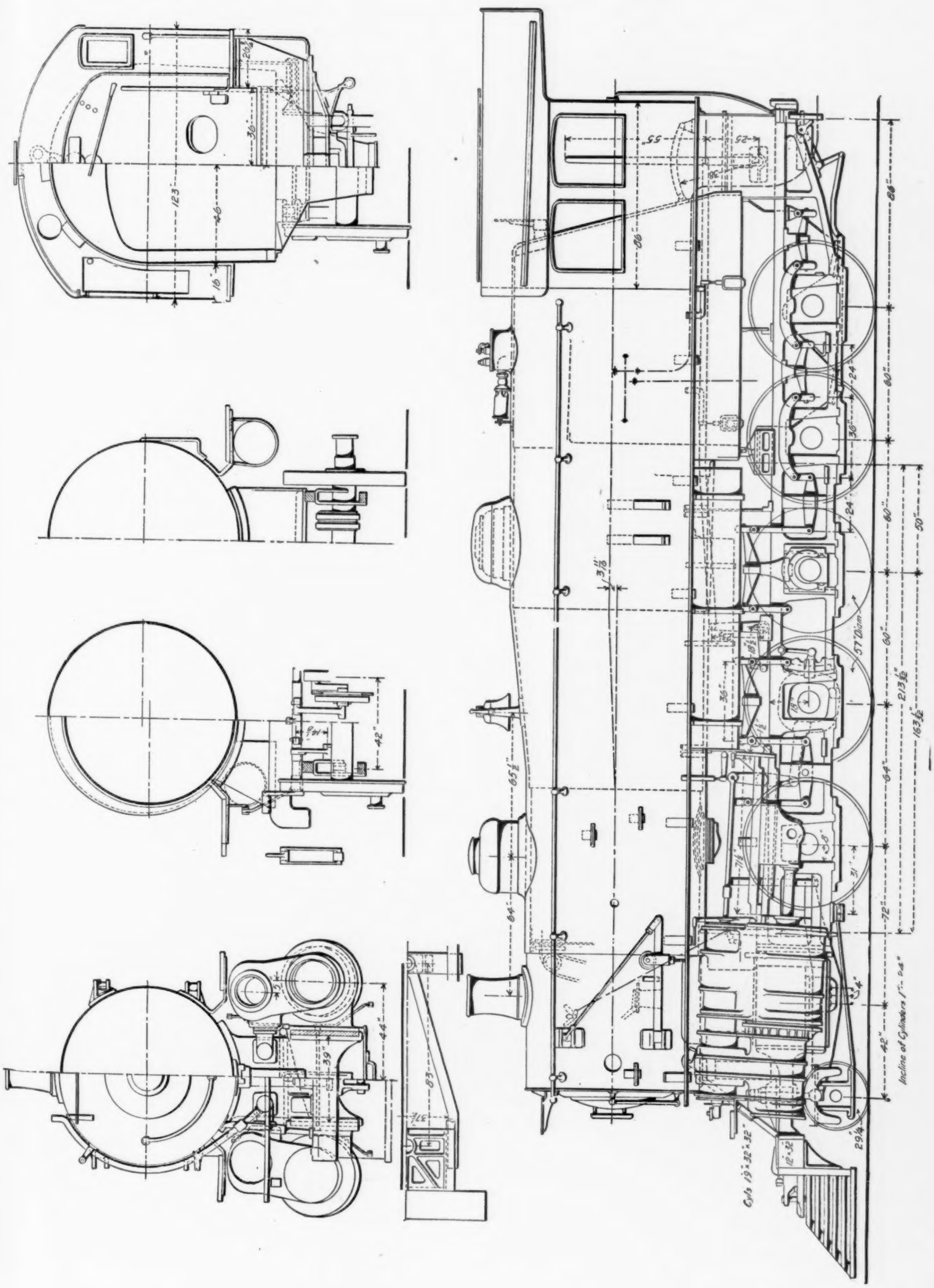


The Heaviest and Most Powerful Locomotive in the World.



Decapod Tandem Compound Freight Locomotive—Atchison, Topeka & Santa Fe Railway.

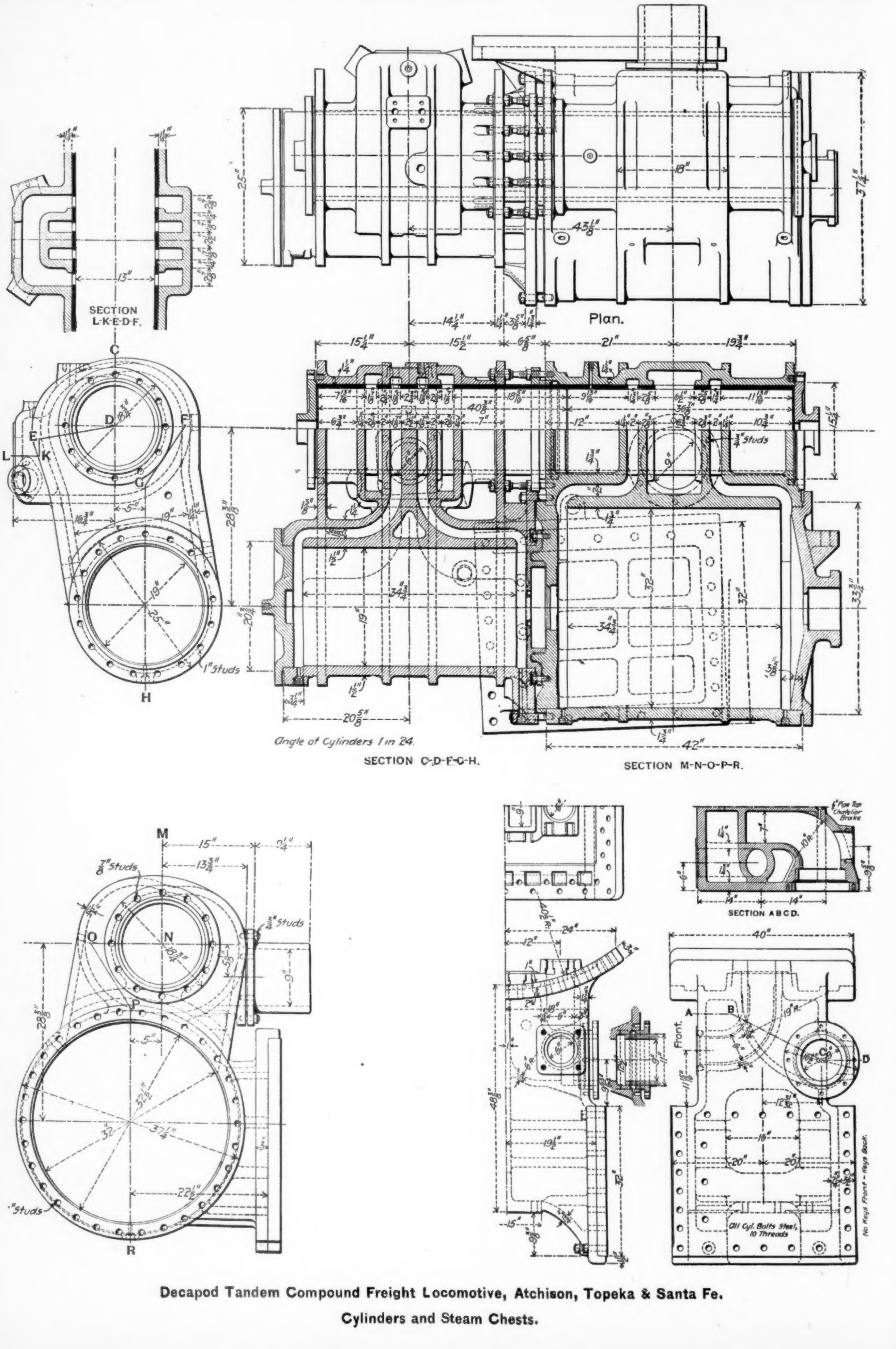
G. R. HENDERSON, *Superintendent Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*



Decapod Tandem Compound Freight Locomotive—Atchison, Topeka & Santa Fe Railway.

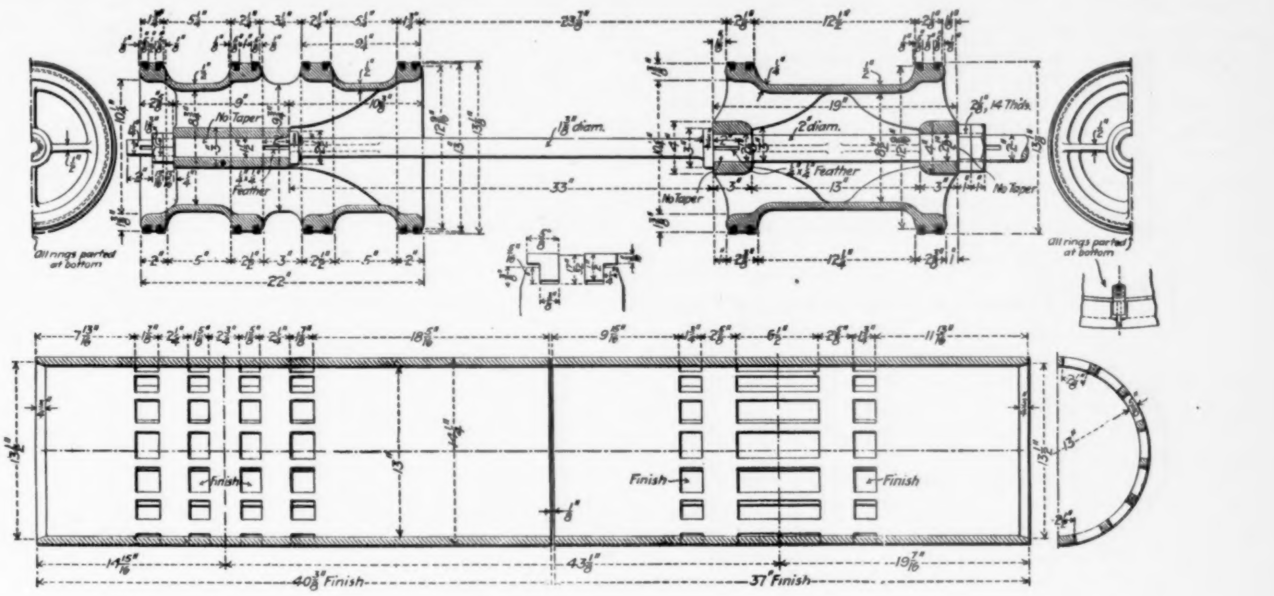
G. R. HENDERSON, *Superintendent Motive Power.*

BALDWIN LOCOMOTIVE WORKS, *Builders.*



Decapod Tandem Compound Freight Locomotive, Atchison, Topeka & Santa Fe.

Cylinders and Steam Chests.



Decapod Tandem Compound Freight Locomotive—A. T. & S. F. Ry.

Valves and Valve Bushings

Wheels, Etc.

Driving, diameter outside	57 ins.
Driving wheels, centers	50 ins.
Truck wheels, centers	29¼ ins.
Driving journals, main	11 x 12 ins.
Driving journals, others	10 x 12 ins.
Truck, type	Swing motion
Truck, wheels	Steel tired
Truck journals	6½ x 10½ ins.
Crank pins, main	8¼ x 8½ ins.
Crank pins, others than main	5 x 4½ ins.

Boiler.

Type	Wagon top
Steam pressure	225 lbs.
Diameter	78¾ ins.
Thickness of sheets	⅞ and 15-16 in.
Type of staying	Radial
Number of fire doors	2
Firebox, length	108 ins.
Firebox, width	78 ins.
Firebox, depth	Front 80 ins., back 78 ins.
Staybolts	1 in. Ulster iron
Crown sheet, thickness	⅜ in.
Tube sheet, thickness	9-16 in.
Side sheets, thickness	⅜ in.
Back sheet, thickness	⅜ in.
Water space	Front 4½ ins., back and sides 4 ins.
Tubes, number	463
Tubes, diameter	2¼ ins.
Tubes, length	19 ft.
Heating surface, tubes	5,155.8 sq. ft.
Heating surface, firebox	210.3 sq. ft.
Heating surface, arch tubes	23.9 sq. ft.
Heating surface, total	5,390.0 sq. ft.
Grate area	58.5 sq. ft.
Smoke stack above rail	15 ft. 6 ins.
Center of boiler above rail	9 ft. 10 ins.

Tender.

Type	8-wheel
Frame	10-in. steel channels
Trucks	Plunger cast steel, diamond frames
Capacity for water	7,000 gals.
Capacity for coal	1[illegible] tons
Wheels	34¼ ins., steel tired
Journals	5 x 9 ins.
Journal boxes	McCord

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

(Chemistry Applied to Railroads—Second Series.)

XXVIII.

(Disinfection of Passenger Cars.)

By C. B. Dudley, Chemist, and M. E. McDonnell, Bacteriologist, of the Pennsylvania Railroad Company.

It will hardly be denied that the subject of the disinfection of passenger cars, stations, waiting rooms and dwellings of employees is one of very great importance to railroads. As knowledge increases, we seem to be learning that there is very much more liability of disease being contracted from occupancy or contact with locations that have been contaminated by persons suffering with certain diseases than was formerly believed, and although the absolute limits of the danger as applied to passenger cars and waiting rooms have not been completely demonstrated by positive experiment as yet, it is still evident that in the case of some diseases, such as smallpox, no one feels satisfied to enter a place so contaminated until the same has been disinfected. And if, as seems probable, it shall be demonstrated by further experiment that there is danger of contracting diphtheria, scarlet fever, tuberculosis, pneumonia, etc., from the occupancy of places contaminated by persons suffering with any of those diseases, it is evident that some efficient means of disinfecting large places, such as passenger cars, waiting rooms, etc., is a very great desideratum. The ordinary fumigation with sulphur, and the treating of infected material with steam for disinfection, are surrounded with some difficulties. The effect of the sulphur gases on metals and on upholstery is very disastrous, and while steam is thoroughly efficient, in order to use it, it is necessary to have large closed spaces into which materials can be placed. Accordingly, when, a few years ago, it was announced that formaldehyde gas apparently successfully met all the requirements of a thoroughly efficient gaseous disinfectant, there was quite a feeling of relief among sanitarians and boards of health, and in many cases railroads began to supply themselves with the necessary apparatus with which to use this new disinfectant.

As time has progressed, however, some disappointment has been experienced in regard to the behavior of formaldehyde. Some boards of health, even at the present time, do not regard formaldehyde as of any value, while positive experiments, made by scientific experts in some cases, have resulted in disappointment. Furthermore, there does not seem to be general agreement as to the conditions under which formaldehyde is efficient as a disinfectant. Some authorities claim, and at first we think it was generally taught, that the gas, in order to be efficient, should be as dry as possible. Others claim that their apparatus gives the proper amount of moisture; while still others specify a certain amount of water to be vaporized per unit of space to be disinfected. Also, the question as to what effect the temperature has on the action of the gas seems to be in doubt. Some authorities think that the gas is absolutely inactive below 45 degrees Fahrenheit, and that it is much more active at higher temperatures than even as low as this point.

In view of this state of affairs, some two years ago experiments were begun in connection with the Chemical and Bacteriological Laboratory of the Pennsylvania Railroad Company, to see, if possible, under what conditions formaldehyde gas did produce disinfection. The questions which we asked ourselves were:

First—Is it essential that the gas should be as dry as possible in order to be efficient?

Second—If not, what influence does moisture have on disinfection?

Third—If moisture is found to be favorable to disinfection, how much moisture is essential?

Fourth—What influence does temperature have on the action of formaldehyde gas as a disinfectant?

Fifth—Are there any other conditions than moisture and temperature that have an influence on the action of formaldehyde gas as a disinfectant?

It is, perhaps, fair to say that it was hardly possible at the beginning of our studies to plan out the investigation as methodically as the questions above given seem to indicate, as the whole field was to us very largely unknown, and we had to feel our way. The above resumé is simply given for convenience in setting forth the results of our studies.

The first point which we tried to settle by experiment was the effect of the presence or absence of moisture on the efficiency of disinfection by means of formaldehyde. Before giving in detail the method of experimentation and the results on this point, it may, perhaps, be wise to spend a few moments with the question of moisture in the air. It is well known that moisture is always present in the air to a greater or less extent, and that the amount of moisture that the air can contain is largely a function of the temperature. Barometric pressure has an influence, but this need not be considered, so far as our experiments are concerned. A few rather elementary figures may not be amiss. When the air is saturated with moisture at a temperature of 40 deg. F. each cubic foot of it contains about 2.80 grains of water; at 50 deg. the amount of water is 4 grains; at 60 deg., 5.70 grains; at 70 deg., 8 grains; at 80 deg., 11 grains, and so on. But it rarely happens that the air is saturated with moisture. The usual condition of the air is a good deal below saturation. The amount of moisture in the air varies with different parts of the country and at different seasons of the year. The usual method of stating the condition of the air as regards its moisture content, or as is commonly said, its "humidity," is by means of a percentage figure. For example, if we say the humidity of the air is 70 per cent., we mean that the air contains 70 per cent. of the moisture that it can contain at the temperature; or, in other words, if the air contains 2.80 grains of water per cubic foot, and the temperature happens to be 50 deg. F., it is evident, since the air can contain 4 grains of water per cubic foot at 50 deg., that the moisture in the air is 70 per cent., that is, 2.80 grains are 70 per cent. of 4 grains, and so on for any other temperature.

One point further should be made clear, namely, there is no necessary relation between the humidity expressed in percentages and the number of grains of water per cubic foot in the air. For example, when the humidity is 70 per cent. and the temperature as above stated is 50 deg., there are 2.80 grains of water per cubic foot in the air. When the humidity is 70 per cent. and the temperature is 70 deg., there are 5.60 grains of moisture per cubic foot in the air; or again, when the humidity is 70 per cent. and the temperature is 80 deg., there are 7.70 grains of water per cubic foot in the air. It will be noted, a little later, that if our experiments are to be trusted, the absolute amount of moisture, that is, grains per cubic foot, has no relation to the efficiency of disinfection by means of formaldehyde. On the other hand, the humidity or percentage of moisture that the air can contain at the temperature has a very important influence on the efficiency of disinfection by means of formaldehyde gas.

Returning now to our experiments. A year ago last winter all the time that could be devoted to this subject was taken up in our bacteriological laboratory with experimental work on this subject. A tight alcohol barrel had the glue soaked out of it, the head taken out and the barrel thoroughly dried. The inside was then coated with paraffine wax, in order to render it impervious to moisture, and the head replaced. The barrel was placed horizontally and an opening made in one of the heads, which was closed by a tight door, and an auger hole (closed with a rubber cork when desired) bored in the head, to enable us to introduce the gas. Along one side of the barrel holes were bored, sufficiently large so that they could be stopped with rubber corks, each cork carrying a half inch or more diameter glass tube, which was closed at the outer end and open at the inner one toward the barrel. This glass tube was divided into two compartments by a little shelf. There were a number of these holes. The object of this glass tube was to carry the test objects which were to be exposed to the action of the gas. The barrel was also fitted with two holes, which were stopped with rubber corks carrying dry and wet bulb thermometers, the wet bulb thermometer being normally removed and a tight cork put in its place, the object of the arrangement being to enable us to determine the amount of moisture in the air. These thermometers read to tenths of a degree, were carefully compared and believed to be fairly accurate. The test objects consisted of the *bacillus coli communis* and *staphylococcus pyogenes aureus*. These test objects were prepared in the proper culture media, and were exposed both on platinum foil and plush, each cork, with its glass tube and shelf arrangement, giving us sufficient space to have both kinds of test objects, both on platinum foil and plush, exposed at one time. In order to dry the air inside the barrel, air which had been passed through chloride of calcium and concentrated oil of vitriol, was sucked through the barrel through proper apertures. We succeeded in getting the moisture out of the air in this way down to a humidity of 18 per cent., the temperature of the room and of course the air in the barrel being from 70 to 90 deg. F. This dry condition of the air being obtained, test objects were introduced into the proper apertures, as above described, and allowed to remain for an hour, until they should come to the condition of dryness which corresponded to the condition of the air in the barrel. Then the proper amount of formaldehyde was introduced by boiling it off from formalin solution, or by the use of para-form decomposed with a little borax water, as will be described later. The amount of formaldehyde gas was varied. In some experiments the amount used was the amount contained in 150 cubic centimeters of 40 per cent. formaldehyde solution per thousand cubic feet of space, but this amount was increased two, three and fourfold in various experiments. The moisture was then measured by means of the dry and wet bulb thermometers, and the gas allowed to act. The test objects were removed at the end of 15 minutes, 30 minutes, 2 hours, 4 hours, 6 hours and 23 hours, and tested for growth. It should be mentioned that the introduction of the formaldehyde always increased the moisture. Also the introduction of the wet bulb thermometer for the time necessary to make the measurements increased the moisture. Both these operations increased the humidity from 15 to 20 per cent., depending on temperatures. It should also be stated that "controls," as they are called, namely, some of the test material which had not been exposed to the gas, was always tested in exactly the same way as that which had been exposed to the gas, to be sure that we were experimenting with live material. It would hardly be possible in a paper of this kind to give the details of all the experiments, as they would occupy too much space. It is perhaps sufficient to say that, although the experiments as above described with dry air were repeated several times, the amount of moisture being always below 45 per cent., we never succeeded in any case in sterilizing test objects as long as the moisture remained at or below that low figure. Even the 23-hour exposure, with the moisture below 45 per cent., in no case ever gave us sterilization.

This point being pretty thoroughly established in our minds, we began to increase the amount of moisture. Depending on the amount that we desired to have present, the moisture was obtained by bubbling air through water, and sucking this air through the barrel, until the desired condition was obtained, or in some cases, in the form of steam from a flask boiled for the purpose, both before the gas was introduced, along with the gas, and after the gas was introduced. The latter procedure, namely, the steam, was employed when we desired to get pretty near to saturation. In this way experiments were made with 50, 55, 60, 70, and so on, per cent. humidity. In brief, our experiments in the alcohol barrel may be summed up as follows: With the moisture in the air below 45 per cent. of the amount that it can contain at the temperature, we never got sterilization, as already stated. With the moisture in the air up to 65 and 70 per cent. and above, we never failed to get sterilization. Between these two points the results were more or less erratic. Sometimes an occasional object would be sterilized, and sometimes none. It should be mentioned that as the amount of moisture increased the time of exposure necessary to produce sterilization seemed to diminish. Indeed, when the moisture in the air approached saturation the test objects withdrawn 15 minutes after the gas was all in, were completely sterile, and this experiment was repeated a number of times.

It will be noted that our experiments do not seem to confirm the idea that dry formaldehyde gas is efficient, but that, on the contrary, certain fairly definite percentages of moisture in the air are essential in order that the gas may do its work. This conclusion, reached over a year ago, was so contrary to what we had been

taught that we were quite skeptical of our results, and did not at the time make any use of them, other than to talk the matter over with bacteriologists, whenever we could get a chance. We felt that the matter was of so much importance that hasty conclusions should certainly be avoided, and that it would be desirable to make experiments on a car, or other larger enclosed space, than our alcohol barrel. Accordingly, the matter was held in abeyance until the advent of cold weather again, since in the summer and fall of the year the amount of moisture in the air is quite large, and it is difficult to make a car tight enough to maintain dry or moist air in it, and we were therefore quite dependent on the outside conditions for our condition of moisture. Before, however, leaving the alcohol barrel, we should mention that a piece of plush, corresponding in size to the amount in a passenger car, was introduced into the alcohol barrel, to see what effect this would have on the moisture in the air. It was found to have a very marked effect. Plush being hygroscopic in its nature, with plush present it was necessary to add a good deal more moisture in order to have the proper percentage show on the dry and wet bulb thermometers than was the case with no such hygroscopic substance present. This point will be referred to later.

In our experiments on a passenger car, which have occupied most of the time during the past winter, we had in mind:

First—To demonstrate whether our conclusions in regard to moisture as obtained from the alcohol barrel were correct as applied to a car.

Second—What is the effect of temperature on formaldehyde disinfection?

Third—Whether any other conditions would manifest themselves in the course of our experiments that would have a bearing on the problem.

An ordinary passenger coach was accordingly chosen, the ventilators closed on the outside with hoods of canvas, the doors, windows and deck sash likewise closed, and dry and wet bulb thermometers on a proper stand were set inside one of the doors, where they could be easily read. In the experiments on the passenger car for convenience only the *bacillus coli communis* was used, and test objects, both on plush, on foil and on filter paper, were employed, as before. The test objects were distributed throughout the car, some in the basket racks, some on the window sills, some on the seats, some on the floor and some in the closets. Twenty-four test objects in all were used with each experiment, and the ordinary controls were made as before. The test objects were always put in place and allowed to stand an hour, before the gas was introduced, and then an hour after the gas was introduced, in order to allow it to act. The gas was boiled off from formalin, always adding a little borax to the formalin, as suggested by Novy, it being found under these conditions that high temperature and pressure are not essential in order to decompose para-formaldehyde. Usually on the car the amount used was about 0.40 of a quart for each thousand cubic feet of space in the car. The gas was introduced through the keyhole, in the opposite end of the car from where the dry and wet bulb thermometers were placed.

It will be readily understood that by warming the air in the car it was easy to get low humidity. The temperature outside varied from 20 to 40 deg. F., and as the amount of moisture possible in the air at these temperatures is less than 3 grains per cubic foot, after heating the inside of the car to 80 degrees, which was often done, the percentage of moisture in the air was readily obtained as low as 22, 25 and 28 per cent., and if the temperature was made a little higher even lower figures could be obtained. A number of experiments were made on a car in this way with the air in the car containing moisture below 40 to 45 per cent. In no case did we succeed under these conditions in getting sterilization; in other words, we absolutely confirmed on the car our experiments with the alcohol barrel. In all perhaps six or eight tests were made with low moisture in the air in a car.

On attempting to increase the amount of moisture in the air we ran across very serious difficulties, owing to the diffusion. It will be understood that a car not being perfectly tight, there being crevices around the windows and underneath the doors, and also around the ventilators more or less, the attempt to maintain a high condition of moisture in such a space was found to be more than we could accomplish, especially in view of the hygroscopic nature of the plush and window curtains. Accordingly at this point we took up the question of the influence of temperature. It will be readily understood that if the temperature is ignored it would be easy to maintain almost any percentage of moisture desired in a car. For example, if the temperature outside was 40 deg. F. and the humidity was 70 per cent., it would require only a few grains of water per cubic foot inside the car to bring the moisture up to saturation if desired. Without going into all the details of all the experiments it may perhaps be sufficient to say that the experiments on the car, ignoring temperature and at high moisture, demonstrated two things, if our experiments are to be trusted: First, we never failed to get disinfection with the moisture above 70 per cent. Second, temperature within the limits of our experiments has no perceptible influence on the action of formaldehyde gas. In other words, even at as low as 25 deg. F. we get complete sterilization of the test objects, provided the amount of moisture was sufficiently high.

It may not be amiss to repeat that our experiments on the car seemed to indicate, first, that with low humidity, up to as high as 45 per cent., we did not get disinfection, irrespective of the amount of gas used. With high humidity, 70 per cent. or above, we never failed to get disinfection. Between these two points the results were more or less erratic and variable. Also temperature at least as low as 32 deg. F., and perhaps safely as low as 25 deg. F., does not retard or prevent disinfection by means of formaldehyde gas, provided a sufficient amount of moisture is present in the air.

One or two interesting points developed in the course of our experiments on the car: First, on a windy day the test objects on the side of the car toward the wind sometimes failed to disinfect, even though the amount of moisture and other conditions were what they should be. This is apparently due to the fact that, as has been stated once or twice, a car not being tight there is more or less air movement in the car, and the gas was probably carried away from that side of the car. Second, when experimenting in a doubtful region of humidity, namely, from 40 to 65 per cent. of moisture in the air, on one or two occasions we got sterilization on the floor and seat of the closet, while we did not get it in other parts of the car. This apparently is explained by the fact that the asphalt floor of the closet was considerably colder than the point at which the moisture was measured in the car, which would have the influence of increasing the percentage of moisture in the air, as already explained. Third, some experiments were made on the car to determine how well the formaldehyde gas penetrates such material, as may occur, as for example, dry sputum. These experiments were not quite as satisfactory as we would like, and we do not feel that this point is completely covered. We could not experiment with the sputum of tuberculosis, as the resources of our laboratory do not involve cultures in living animals. Accordingly the cultures we had already experimented with were mixed with healthy sputum, dried down, and then exposed in the regular way. We always got sterilization of these test objects, provided the amount of moisture was sufficient, but the controls were not satisfactory, indicating perhaps that the *bacillus coli communis* does not flourish in a culture medium containing considerable healthy sputum, or that the drying was detrimental. The point, therefore, of the penetration of the gas into dried sputum is not quite satisfactorily settled by our experiments.

This is the place perhaps to mention that thus far we have made no experiments on a Pullman car, with its wealth of upholstery. So far as our experiments, however, have gone we are clearly of the opinion that it will take a very much larger amount of moisture, introduced in some way, in order to get sterilization in a Pullman car than with an ordinary passenger coach, provided, of course, the air does not happen to have the proper amount of moisture in it when the experiment is made.

A few words on how to get the moisture in the air may not be amiss. We tried two different methods; one was by boiling in a large amount of moisture along with the gas or preceding the gas. This method is not to be recommended, we think, as the heat which goes in with the steam raises the temperature of the car and makes the maintenance of the percentage of moisture more difficult, the tendency of the air inside and outside the car to intermingle through the crevices being increased by difference in temperature. The other method consisted in sprinkling the floor. This has the two fold advantage of supplying the moisture required and at the same time lowering the temperature in the car and making it easier to maintain the humidity nearer saturation. It seems fairly probable that possibly spraying through the keyhole for those places into which it is not desirable to enter may be a thoroughly efficient means of getting the moisture, and indeed there are some indications that spraying may be the best means of all of obtaining the moisture in the space to be disinfected.

Another point which should be mentioned is that there may be some difficulties connected with getting rid of the gas after the space has been sterilized. Our usual procedure has been to open the doors and windows and allow the car to ventilate itself, but we have always found that when a car is heated after such a procedure sufficient material remains in the car to cause some difficulty. This difficulty diminishes if the car is heated up to 70 or 80 deg. F. and then ventilated, and then heated up a second time and thoroughly ventilated. A third heating shows very little odor. This procedure we commonly employed between experiments, so as not to have anything carried over from one test to another, but it is obvious that if cars are disinfected in the summer, and do not completely lose the effects of the disinfection before winter, there may be some trouble. The use of ammonia gas to overcome this difficulty did not prove entirely satisfactory. The point remains for further study, with the expectation on our part that two or three times heating up to a pretty high temperature and ventilating between will probably make cars quite satisfactory to use.

It might perhaps be fairly stated that it is the intention to prepare definite instructions in printed form, embodying the results or our studies on the subject, to be used by the employees of the railroad company who do this work of disinfection. This has not yet been done, but will receive attention as soon as possible.

In view of the work that has been done on this subject, which has been summarized above, we are inclined to think we are warranted in trusting the following conclusions:

First—That in order to get efficient disinfection it is essential to have the air of the space to be disinfected contain at least 70 per cent. of the moisture that it can contain at the temperature.

Second—That we are fairly safe in ignoring temperature in the matter of disinfection with formaldehyde down to as low, at least, as 32 deg. F.

Third—That it would be desirable not to attempt to sterilize artificially heated rooms or spaces on account of the difficulty of maintaining the proper amount of moisture in the air.

Fourth—That a hygrodeik or some means of determining the amount of moisture in the air is an essential to every sterilizing outfit.

Fifth—That the necessary moisture can probably, in almost all cases, be satisfactorily obtained by sprinkling the floors. In cases where it is not desirable to enter the space on account of fear of infection the moisture can be sprayed in through the keyhole in the door.

Sixth—Since formalin, the usual commercial form of obtaining the material, is cheap, it is probably better to use an excess than to try to diminish the amount to the smallest figure which will give success, and that it would be desirable to charge the apparatus with not less than 0.40 of a quart of formalin for each thousand cubic feet of space to be disinfected.

Seventh—That if a small amount of borax is added to the formalin solution it is not essential to use high temperatures and pressure in the generator.

Eighth—It is probable that it would be unwise to attempt to disinfect a coach or a room on the windy side of a building when high winds are blowing.

Ninth—That it is probably good practice after the moisture is introduced to allow twenty minutes or half an hour to elapse before the gas is introduced, in order to have the moisture disseminate itself, and that after the gas is introduced, provided sufficient moisture is present, an hour is abundant for the action of the gas. Of course all the windows and doors should then be opened, to give thorough ventilation.

It is simple justice to say that in the planning and carrying out the large number of experiments epitomized above the chances for consultation with and the suggestions of Mr. F. N. Pease, principal assistant chemist of the Pennsylvania Railroad Company, have been of very great value.

THE SUPERINTENDENT OF MOTIVE POWER AND THE STOREKEEPER.

By G. F. Slaughter,

General Storekeeper, Chicago & Northwestern Railway.

It is usually conceded that the store and motive power departments in railway work are closely related. In times of financial prosperity, as at present, this is especially true. Business activity brings added responsibility to both. For instance, at such times locomotives are usually overworked, and material with which to repair them is difficult to procure, though planned for far in advance of actual requirement. Hence there must be hearty co-operation; first, between the superintendent of motive power and the general storekeeper; second, between the master mechanic at the division shop and the local storekeeper.

To achieve the best results, the two departments should be interdependent, though in no sense under one head; for one branch of the service requires mechanical instinct, the other that of the merchant. The mechanical department creates, while the store department supplies the demand.

To be of proper assistance, the storekeeper must possess a fair knowledge of the locomotives on the division where he is employed. Usually there are many classes, and he must know of what these consist. This is not sufficient, and he must seek further information from the detail drawings secured from the mechanical office. Some parts of locomotives last much longer than others, and it is his business to know just what these parts are, to prevent a shortage of that for which there is a demand, or an overstock of useless material; otherwise his motive-power friend will soon discover that he has everything in stock except the particular part desired.

To secure appropriations for shop improvements, such as machinery, etc., the mechanical department is usually required by the management to assume the obligation of cutting down the cost of output. Before attempting to cut it down, however, the cost must be known. For this purpose simple intelligent cost-accounting is required. When, as on some railways, the storekeeper is entrusted with this, he is of far greater value to the mechanical department. He must furnish the cost of all output, impartially, upon its completion, exhibiting the rate of compensation, the time consumed, kind and quantity of material and labor used. Then only can the mechanical department distinguish between labor wisely and unwisely expended, and compare the ability of their men, whether foremen or mechanics. The following examples show how such information may be presented:

Example "A"

Cost of manufacturing ten freight whistles on lot No. 3583, dated March 3, 1902, in M. P. & M. Department. Completed April 21, 1902. Shops, April 22, 1902. No. 1914, M. P. & M. file No. 983.

			$			
5 feet tubing, 33¾ lbs.	at	c.				
10 castings No. 910, 35 lbs.	"					
8 feet 1 in. soft steel, 20 lbs.	"					
10 castings No. 764, 9 lbs.	"					
10 rivets, ⅜ x 1¾, ½ in.	"					
10 cotters, ⅛ x 1	"					
10 whistle castings, 239 lbs.	"					
		Exp.	—	—		
Labor						
Machine Shop.						
	Hours. Rate.	Total.				
Check 1367	at					
" 1381	"					
" 1376	"					
" 1374	"					
" 1386	"					
" 1366	".					
	Superintendence		—	—		
	Total					
Credit						
10 lbs. brass scrap	at		—	—		
		Total cost	==	=		

Remarks. April cost $....per each.
March cost $.... " "
February cost $.... " "
January cost $.... " "

Approved:

....
Supt. M. P. & M. General Storekeeper.

Example "A" is for the manufacturing of ten locomotive whistles. Aside from the material, with its cost, is shown the labor performed in each shop; also, the men who performed it, identifying them by check numbers. In Example "B," aside from the opening details, you will observe the quantity

Example "B"

Cost of manufacturing 28,533 lbs. engine bearings (solid) on lot No. ...., dated ...., in Brass Foundry Department. During .... March, 1902. No. ....

Quantity.	Items.	Price.		Amount.
Pounds	molasses	at c.	gal.	
"	flour	"	cwt.	
"	sand	"	ton	
"	charcoal	"	cwt.	
"	egg coal	"	ton	
Nos.	crucibles	"	Hd. Nos.	
Pounds	copper	"	lb.	
"	coke	"	ton	
"	tin	"	lb.	
		Exp.		
Labor				
Superintendence				
	Total cost			

Remarks. March cost.... c. per pound.
February " .... " " "
January " .... " " "
December " .... " " "
November " .... " " "
October " .... " " "

Approved:

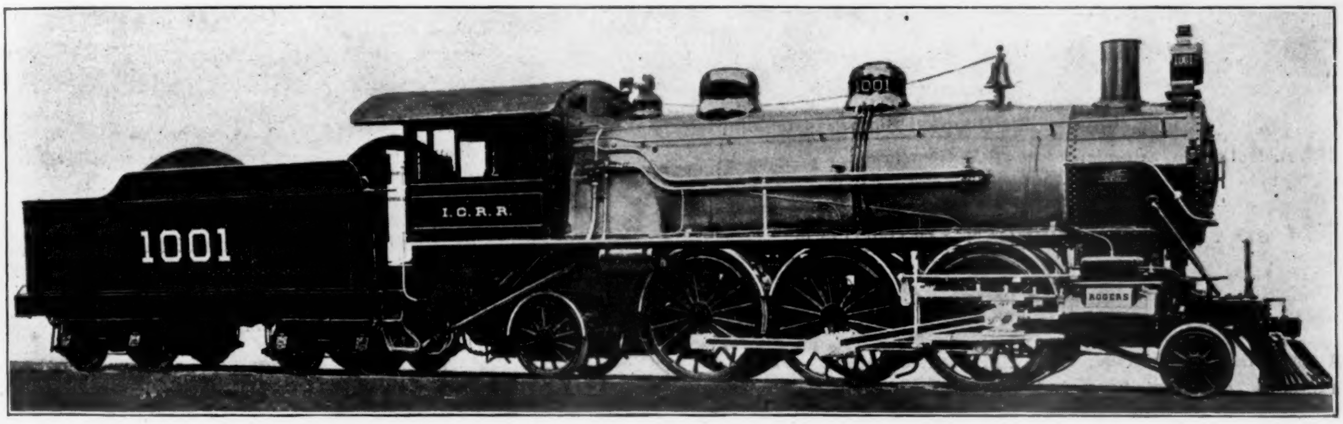
....
Supt. M. P. & M. General Storekeeper.

PRAIRIE TYPE PASSENGER LOCOMOTIVE.

Illinois Central Railroad.

This handsome prairie type engine is one of a lot of twenty now building for the Illinois Central by the Rogers Locomotive Works.

This road has a large number of ten-wheel passenger engines and is now receiving the Atlantic and prairie type wide-firebox engines for the first time, the intention being to make long time tests of the performances of the three types from which to determine future practice. Among the features of this prairie type engine is a forced lubrication of the driving boxes from the cab through pipes which appear in the engraving. The trailing truck has a pair of yokes for each box, and from these yokes the load is applied to the boxes through initial stability links or "three-point" hangers. In the following table the chief characteristics of the engine are summarized:



Prairie Type Passenger Locomotive—Illinois Central Railroad.

WM. RENSHAW, *Superintendent Machinery.* ROGERS LOCOMOTIVE WORKS, *Builders.*

and kind of material used; finally, the division of labor and the finished product, with the usual charge for superintendence; giving the total cost compared to that of previous months.

To the inquiring mind such statements suggest improved methods and, where practicable, the substitution of cheaper materials, and often less expensive labor. A catalogue of locomotive castings, alphabetically arranged, and containing a numerical index of the patterns, affords a ready reference for the store and motive power departments. Such a book is of inestimable value, difficult to compile at the start, but hard to dispense with after once inaugurated.

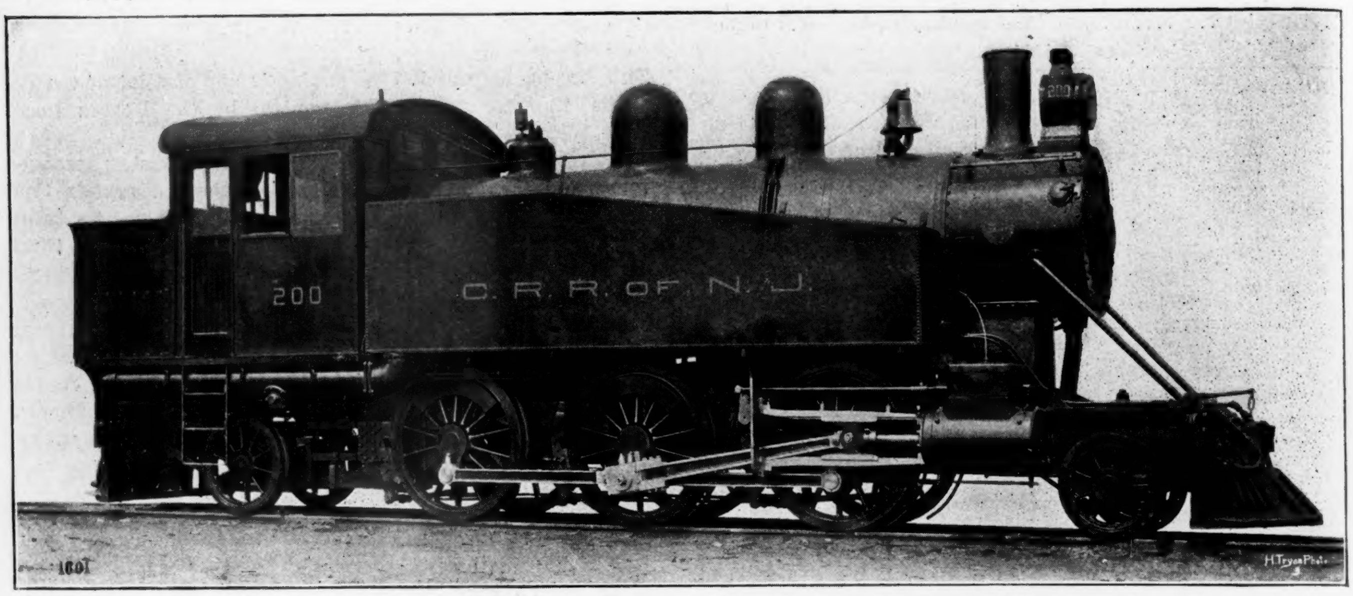
Now, to enable the storekeeper to provide material for repairs in due season, the mechanical department must keep him advised as far in advance as possible as to just what classes of locomotives are expected to be shopped, and the nature of their repairs. For example, a certain locomotive will need a pair of cylinders, another a firebox, while a third will need general repairs. The material for such repairs must be on hand far enough in advance to complete all necessary machine work with as little delay as possible after the locomotives enter the repair shop. A locomotive unemployed represents idle capital.

To obtain material and finish without delay the many items essential to a locomotive requires forethought, constant effort, and eternal vigilance in both departments. While we rely on human agencies errors will occur, both excusable and inexcusable; but even errors are not without good, since the alert, profiting by past experience, rarely make the same mistake twice.

The J. S. Toppan Company, 77 Jackson boulevard, Chicago, has brought out a new car seal, which seems to be an excellent device. It is made of a single piece of tin, and is applied without tools of any kind.

Gauge	4 ft. 8½ ins.
Cylinders	20 x 28 ins.
Driving wheels, diameter	75 ins.
Driving wheel base	13 ft. 6 ins.
Total wheel base of engine	30 ft. 9 ins.
Weight on drivers	144,000 lbs.
Weight on truck	22,000 lbs.
Weight on trailers	37,000 lbs.
Weight, total	203,000 lbs.
Boiler, diameter	68 ins.
Heating surface, tubes	3,333 sq. ft.
Heating surface, firebox	201 sq. ft.
Heating surface, total	3,534 sq ft.
Grate area	51 sq. ft.
Boiler pressure	200 lbs.
Tubes	335
Tubes, size outside	2 ins.
Tubes, length	19 ft.
Firebox, length	102 ins.
Firebox, width	72 ins.
Driving axle journals	9½ x 12 ins.
Engine truck wheels	33 ins.
Trailing wheels, diameter	48 ins.
Tender, water capacity	7,000 gals.
Tender, coal capacity	15 tons
Tender journals	5½ x 10 ins.

The "Pocket List" has won its suit and the Supreme Court of the District of Columbia has decided the injunction case in favor of that publication, allowing it to continue its distribution through the mails at the rate for second-class mail matter. This is the first injunction case brought to determine the power of the postmaster general to charge the higher rate under the new departmental regulation. It is an important victory.



Six-Coupled Suburban Locomotive—Central Railroad of New Jersey.

WM. MCINTOSH, *Superintendent of Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*

SIX-COUPLED SUBURBAN LOCOMOTIVE.

Central Railroad of New Jersey.

A suburban locomotive, with the prairie type of wheel arrangement, has just been built by the Baldwin Locomotive Works for the Central Railroad of New Jersey to suit the conditions of suburban traffic on that road. This is another instance indicating the necessity for special engines for work requiring high accelerating power, which is one of the conditions making suburban schedules particularly severe. More of this type will be built if the results of experience are satisfactory.

This engine is much lighter than that of the New York Central, illustrated in April, page 114. It has side tanks, which are filled through pipes from the rear, and the weight is carried on 10 wheels instead of 14, as in the case of the New York Central engine. The following table gives a summary of the principal characteristics of the design:

SIX-COUPLED SUBURBAN LOCOMOTIVE,

CENTRAL RAILROAD OF NEW JERSEY.

Number to be built	10
Gauge	4 ft. 8½ ins.
Cylinders	18 x 26 ins.
Valves	Balanced, slide
Boiler, type	Straight
Boiler, diameter	60 ins.
Boiler, pressure	200 lbs.
Fuel	Hard coal
Staying	Radial
Firebox, length	109 ins.
Firebox, width	72 ins.
Firebox, depth, front	55¼ ins.
Firebox, depth, back	44¾ ins.
Firebox, sheets	⅜ in.
Tube sheets	½ in.
Boiler sheets	⅝ in.
Water spaces	Front 3½ ins., others 3 ins.
Tubes, number	249
Tubes, size	2 ins.
Tubes, length	13 ft.
Heating surface, firebox	137.4 sq. ft.
Heating surface, tubes	1,684 sq. ft.
Heating surface, total	1,821.4 sq. ft.
Grate area	54.5 sq. ft
Driving wheels, diameter	63 ins.
Driving journals	8½ x 12 ins.
Truck wheels, front	36 ins.
Truck journals, front	7 x 12 ins.
Trailer wheels	42 ins.
Trailer journals	7 x 12 ins.
Wheel base, driving	14 ft.
Wheel base, total	31 ft. 8 ins.
Weight on drivers (estimated with half supply of water and coal)	108,000 lbs.
Weight, total (estimated with half supply of water and coal)	165,000 lbs.
Tanks, capacity for water	3,000 gals.
Tractive power	22,700 lbs.

The Pittsburg Blue Print Company, Park Building, Pittsburgh, Pa., have received orders aggregating 50,000 yards of "Rapid" printing blue print paper during the month of May.

The Handy Car Equipment Company, Old Colony Building, Chicago, has taken over the sale of the American Dust Guard, manufactured and formerly sold by the American Dust Guard Company, of Columbus, Ohio.

The Boston Belting Company, Boston, Mass., are now prepared to weave their "Universal" cotton jacket over any kind of rubber hose. The cotton jacket consists of a heavy seamless fabric which they weave directly over the rubber hose, thus greatly increasing its strength and wearing qualities. It is claimed that it will not unwind if a single strand is cut, that it prevents kinking of the hose, and when painted it is waterproof.

Mr. J. W. Duntley, president of the Chicago Pneumatic Tool Company, has just returned from a trip through Europe. While there he secured orders for an aggregate of 2,700 "Boyer" and "Little Giant" pneumatic tools, as well as for 25 "Franklin" air compressors, for early delivery. Mr. Duntley states that Europeans now realize the absolute necessity of using labor-saving tools to reduce the cost of manufacture and counteract the influence of the "American invasion" (which is causing widespread alarm in commercial circles) and enable them to compete for the markets of the world. The remarkable increase in the sales of pneumatic tools in foreign countries recently may be attributed, in a measure, to the cause above mentioned and also to the fact that the opposition to pneumatic tools by workmen, on account of their labor-saving qualities, has been overcome.

The Ajax Metal Company, Philadelphia, Pa., announce that they have recently acquired additional ground adjoining their present plant and will erect a building, 100 x 175 feet, for the refining of all kinds of brass scrap, under patents granted their Mr. G. H. Clamer for a process of eliminating zinc, iron, manganese, aluminum and other impurities. They will be in position also to work the ores, such as copper matte and galena, direct from the mines. They expect, under these patents, to be able to produce a metal for bearings which will cost considerably less than the market prices ruling to-day. It was the manufacture of Ajax plastic bronze that led Mr. Clamer to recognize the feasibility of his process for eliminating all impurities from metals. It is expected that the additional plant will be ready for operation in September.